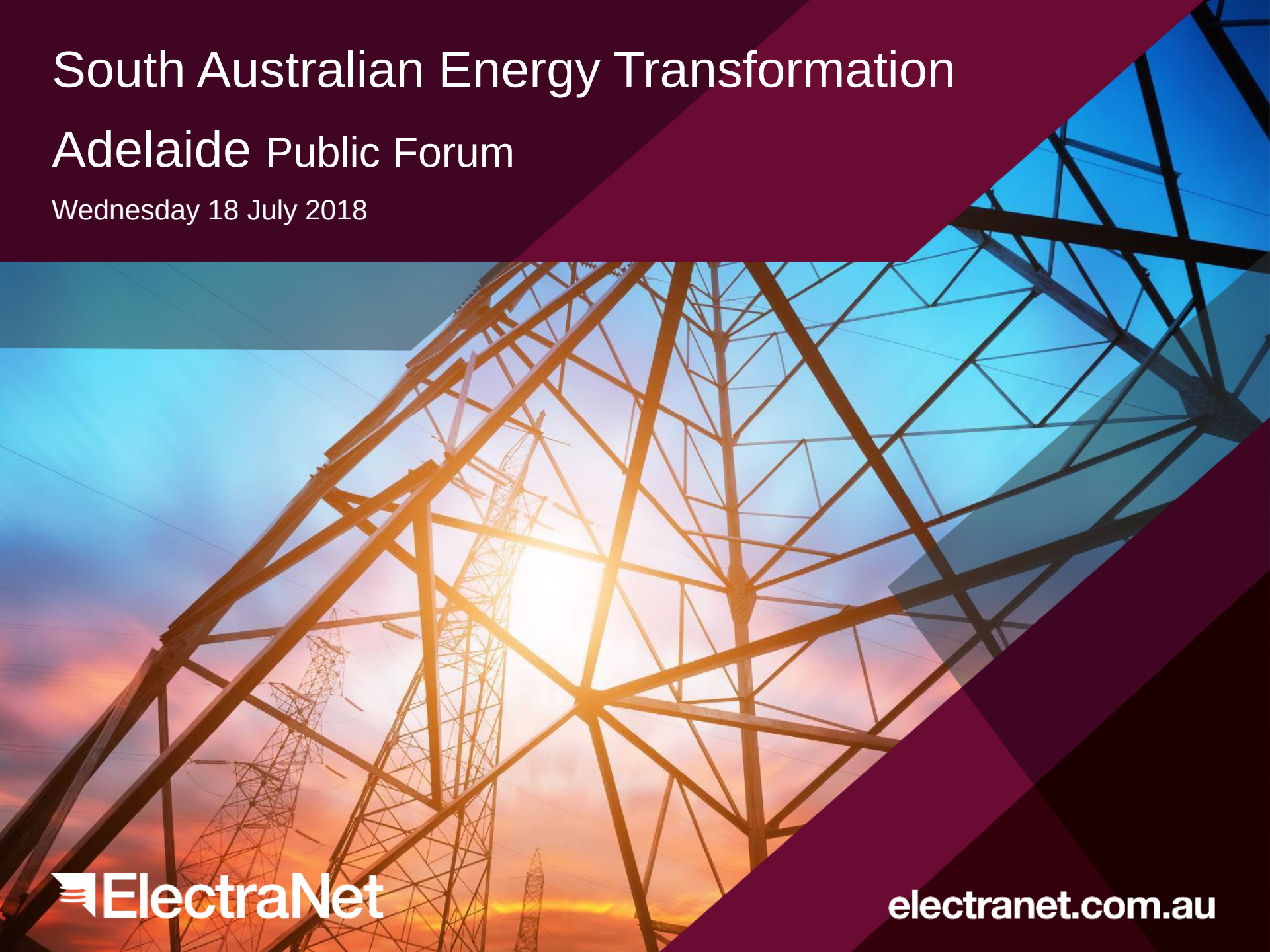
# South Australian Energy Transformation

## Adelaide Public Forum

Wednesday 18 July 2018



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# What is SA Energy Transformation?

- An ElectraNet led project to investigate interconnector and network support options aimed at…
  - reducing the cost of providing secure and reliable electricity in the near term
  - facilitating the medium to longer-term transition of the energy sector across the National Electricity Market to low emission energy sources
- Includes an economic cost benefit (RIT-T) assessment of feasible options to support this energy transformation
- Our investigation has been undertaken in consultation with national and jurisdictional planning bodies AEMO (National and Victoria), Powerlink (Queensland) and TransGrid (NSW)

# Our purpose

- We published a Project Assessment Draft Report (PADR) on 29 June 2018
- Our purpose today is to clarify understanding of the draft report findings and invite your feedback
- Feedback will be considered as input to the next and final stage of ElectraNet's investigation

# Outline

| Item | Notes | Lead |
|---|---|---|
| 1. Opening, welcome and overview | Provide high level overview of context and PADR outcomes | Rainer Korte (15 min) |
| 2. Interconnector options | Summary of options considered | Vinod Dayal (10 min) |
| 3. Non-interconnector options | Summary of non-interconnector option and how constructed | Hugo Klingenberg (10 min) |
| 4. Market benefits assessment | Present outcomes along with high level summary of approach and assumptions | Brad Harrison (20 min) |
| 5. AEMO Integrated System Plan | Overview of ISP including what is says about new SA interconnection | Elijah Pack (20 min) |
| 6. Q&A | Panel discussion | Rainer Korte (40 min) |
| 7. Summary, next steps and close | | Rainer Korte (5 min) |

# Context and overview

Rainer Korte, Executive Manager Asset Management

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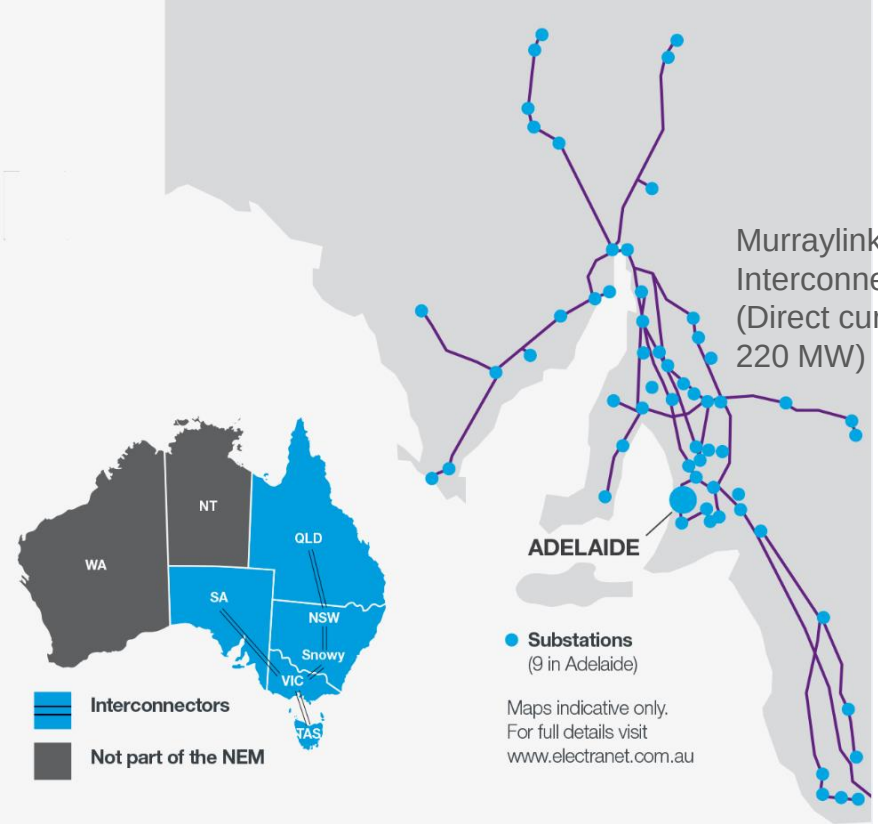
# Context

## South Australia (SA) is at the forefront of energy transformation

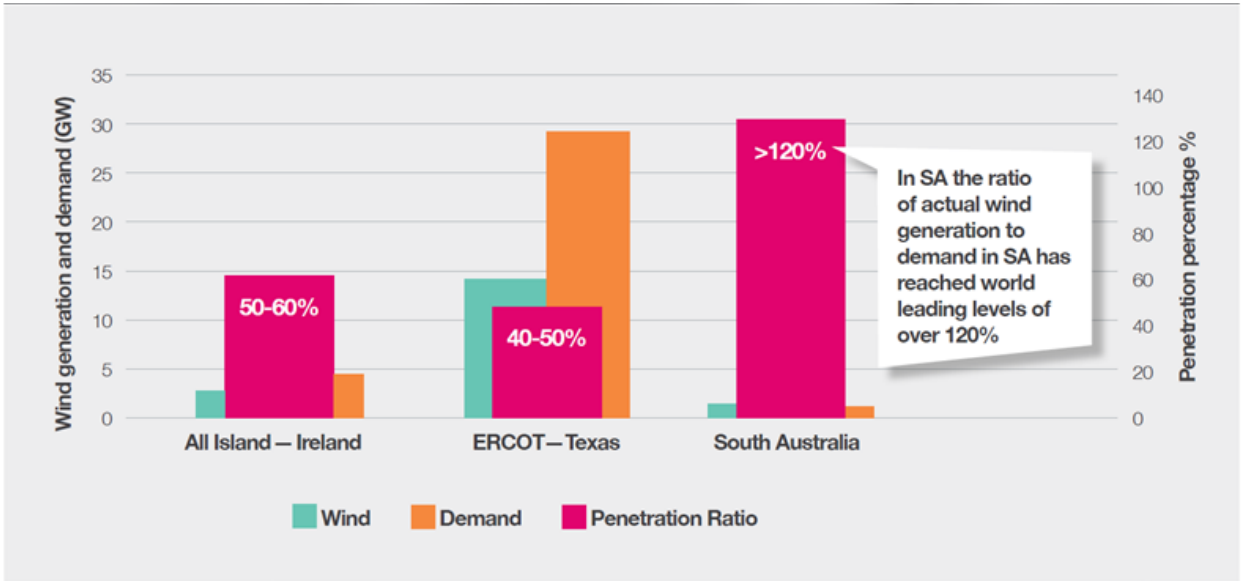



NEM – National Electricity Market
AEMO – Australian Energy Market Operator

- Leading levels of integration of intermittent wind and solar energy compared to demand
- Last coal fired power station closed 2016
- Reliance on gas generation and higher gas prices is impacting electricity prices
- SA separation and load shedding events have led to heightened concerns about power system security
- New measures have been introduced by AEMO and the SA Government to manage power system security
- Ongoing policy drivers to lower carbon emissions, new technology and customer choice continue to drive energy transformation

# SA Energy Transformation

- New challenges are emerging from the combination of relatively high levels of intermittent generation and a relatively isolated and weakly interconnected system



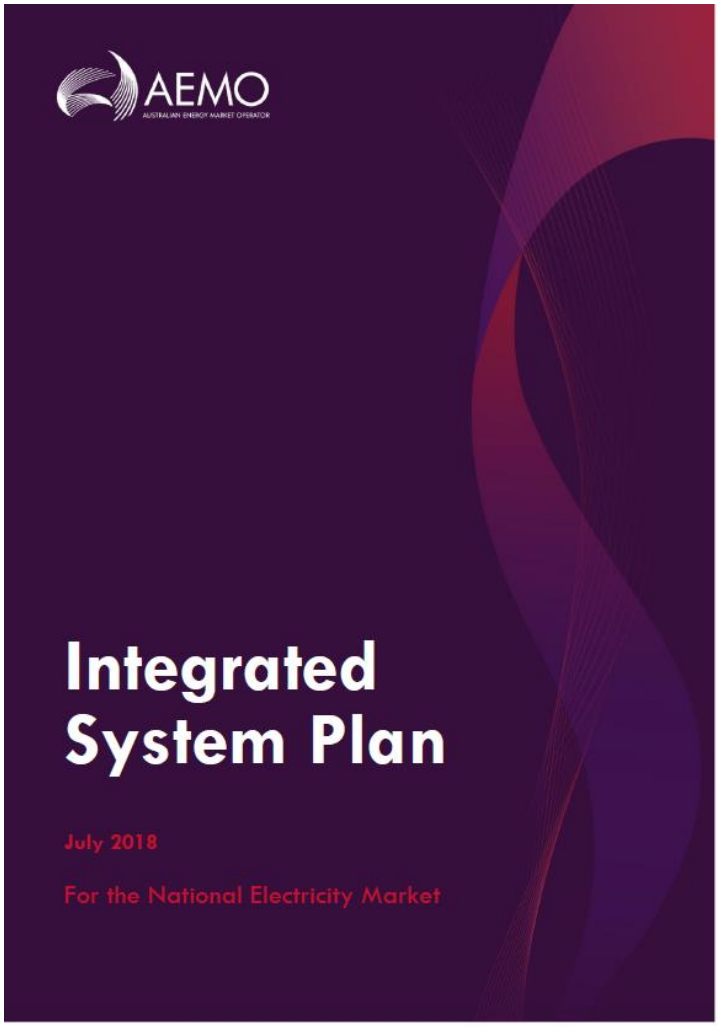

Source: AEMO, South Australian System Strength Assessment, September 2017.

- SA is unique compared with other major systems with high levels of intermittent wind:

**Denmark** – has many interconnections with neighbouring countries
**Ireland** – restricts non-synchronous generation to 55% penetration levels
**Germany** – has many interconnections with neighbouring countries
**Texas** – has low levels of wind relative to system demand

# AEMO Integrated System Plan

- Developed in response to the Federal Government commissioned “Finkel Review” recommendations and published 17 July 2018
- Key themes…
  - Large amounts of coal fired generation is expected to close over the next 20-years (about a third of current energy supplies)
  - This generation will be largely replaced with large and small scale solar and wind generation
  - This transformation needs to be supported by large amounts of energy storage and targeted investment in transmission between regions – to minimise costs and enable an affordable, reliable and secure energy system for energy customers now and into the future



# Consultation to date

## Project Specification Consultation Report (PSCR) and other associated reports from November 2016

| | | |
|---|---|---|
| Project Specification Consultation Report | *(PDF, 2 MB)* | Download |
| Fact Sheet - Exploring South Australia's Energy Transformation | *(PDF, 980 KB)* | Download |
| Presentation - South Australian Energy Transformation forum | *(PDF, 2 MB)* | Download |
| Market Modelling Approach and Assumptions Report | *(PDF, 759 KB)* | Download |
| SAET Supplementary Information Paper | *(PDF, 670 KB)* | Download |

- All information is available at [electranet.com.au](electranet.com.au)

# Submissions received

Summary of submissions to earlier consultation papers

| From | No. | Topic | No. |
|---|---|---|---|
| Jurisdictional planning bodies | **3** | Network options | **5** |
| Market participants | **14** | Proposals for non-network options | **18** |
| Advisory bodies/ universities | **5** | General feedback on the RIT-T process | **7** |
| Manufacturers and other proponents | **13** | Feedback on market modelling approach | **10** |
| **Total submissions** | **35** | **Total submissions** | **40** |

Totals are not the same as some submissions address multiple topics

# Why we delayed publication of draft report

Key policy and regulatory developments since release of the PSCR


Our draft report takes these changes into account



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# Draft report findings

- A new high capacity interconnector between South Australia and New South Wales would deliver substantial economic benefits as soon as it can be built
- Our work has been closely coordinated with the development of AEMO's Integrated System Plan
- We have investigated four broad credible options to deliver net market benefits and support energy market transition through:
  - Lowering dispatch costs by increasing access to supply options across regions
  - Improving access to high quality renewable resources across regions
  - Enhancing security of electricity supply in South Australia
- The recommended option delivers positive net benefits across all reasonable future scenarios



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# Overview of recommended option

## Details

- Location: A new double circuit transmission line between Robertstown in the mid-north of South Australia to Wagga Wagga via Buronga in New South Wales
- Planned capacity: 800 MW
- Voltage: 330 kV
- Length:  About 920 km

## Delivery

- ElectraNet would partner with TransGrid, the transmission network service provider in NSW
- ElectraNet would fund the capital works in SA and TransGrid would fund the works in NSW

## Cost

- Total cost is estimated to be $1.5bn (SA $400m and NSW $1.1bn)

## Benefits

- New interconnector is estimated to deliver net market benefits of about $1bn
- Wholesale market fuel cost savings of $100m per annum putting downward pressure on electricity prices
- Independent modelling by ACIL Allen estimates that annual residential customer bills would reduce by up to about $30 in SA and $20 in NSW

## Timing

- Subject to obtaining necessary approvals, the project could be delivered by 2022 to 2024

# We welcome feedback on our draft report

**Project Assessment Draft Report (PADR) and Associated Reports - June 2018**

| | | |
|---|---|---|
| Project Assessment Draft Report | *(PDF, 3 MB)* | Download |
| Information Sheet - South Australian Energy Transformation | *(PDF, 3 MB)* | Download |
| Basis of Estimate for PADR | *(PDF, 1 MB)* | Download |
| Network Technical Assumptions | *(PDF, 617 KB)* | Download |
| SA NSW Interconnector - Preliminary Projected Impact on Electricity Prices (ACIL Allen) | *(PDF, 342 KB)* | Download |
| Gas Price Forecast Review | *(PDF, 134 KB)* | Download |
| Consolidated Non-Interconnector Option | *(PDF, 1 MB)* | Download |
| Market Modelling Report | *(PDF, 1 MB)* | Download |
| Market Modelling and Assumptions Data Book | *(XLSX, 213 KB)* | Download |
| RIT-T Market Modelling High Level Review (Oakley Greenwood) | *(PDF, 182 KB)* | Download |

- All information is available at [electranet.com.au](electranet.com.au)
- Submissions are due by 24 August 2018



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# Interconnector options

Vinod Dayal, Principal Planning Engineer

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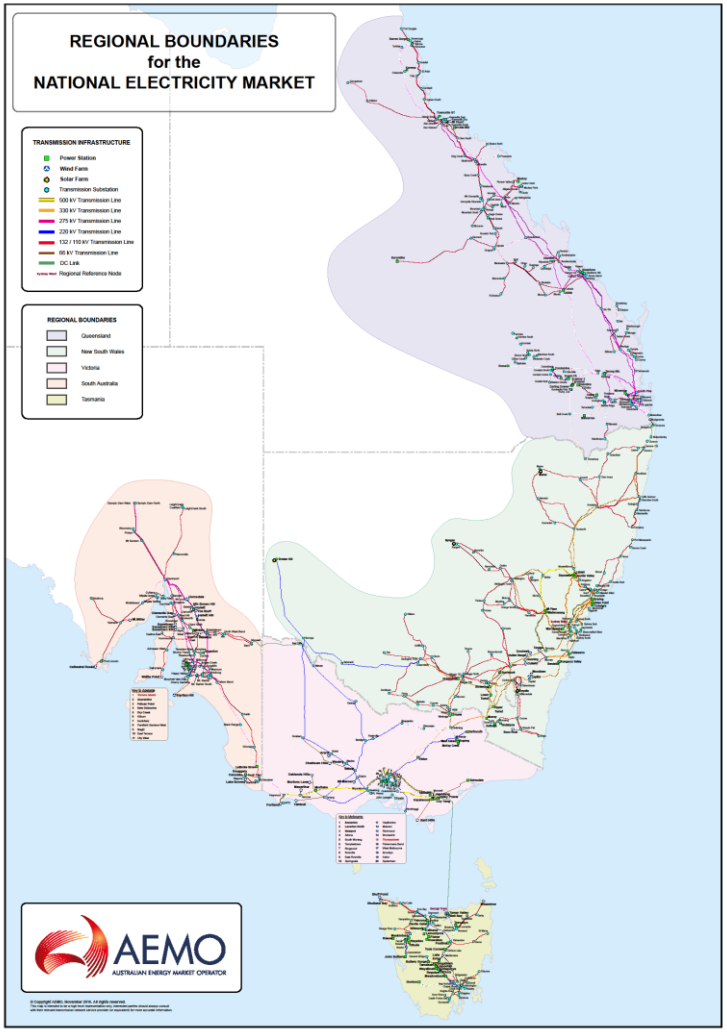
# Network option considerations

- Feedback from consultation to date
- Independent flow path needed
- Sizing to match parallel interconnector paths
- Closing the NEM loop
- Distance, technology and transmission voltage
- Connectivity
- Reliability and security
- Transfer capability and losses
- Sharing between interconnectors
- Impact on constraints in the NEM

**Network options were developed in consultation with Jurisdictional Planning Bodies**



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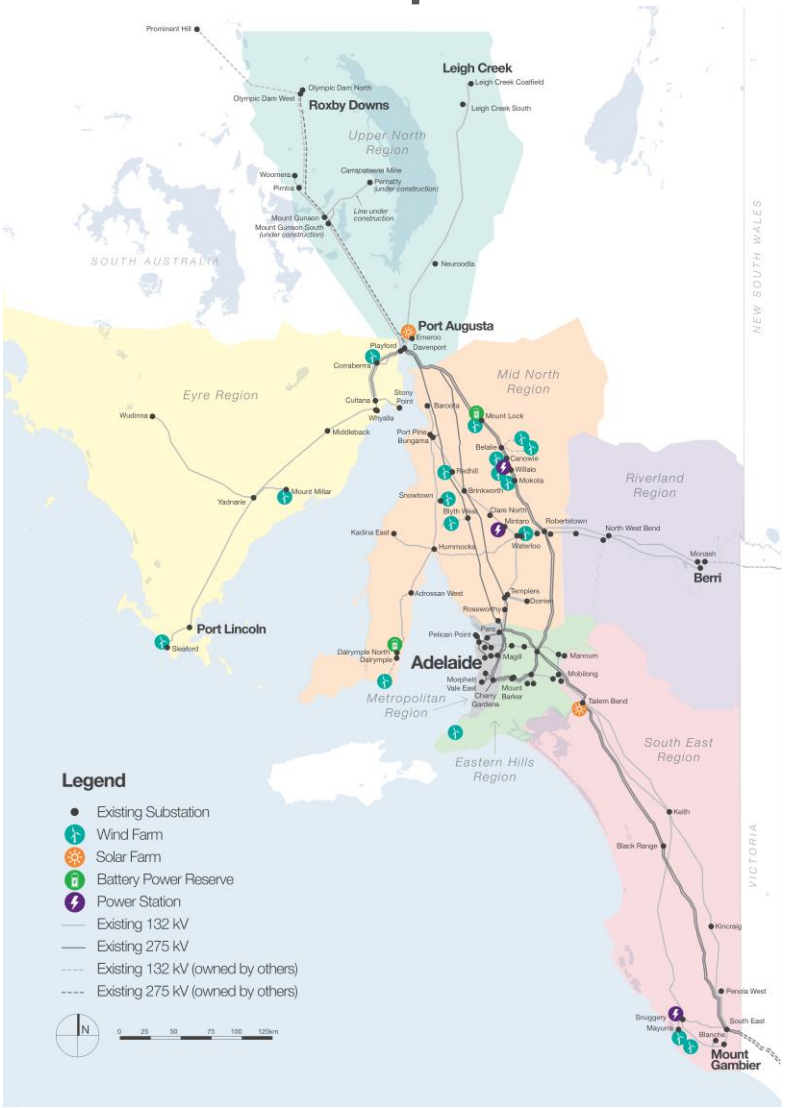
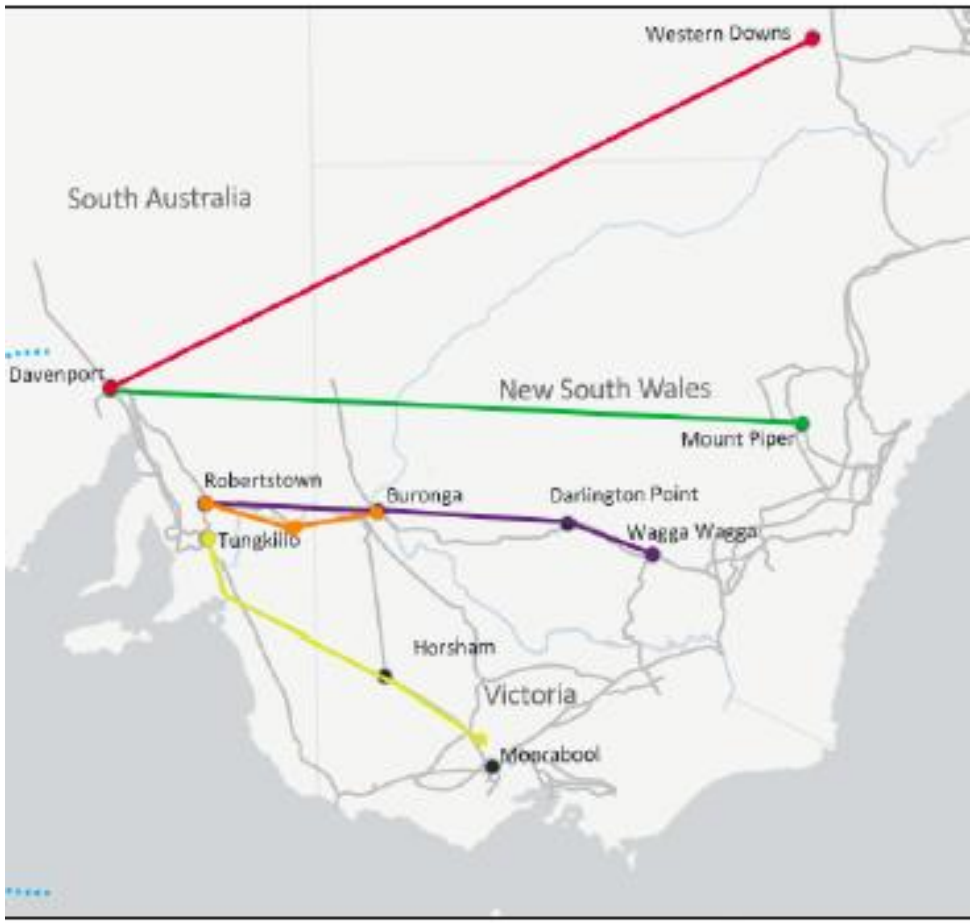
# Network options



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# Options and transfer capability

| Description | Distance (approx. km) | Nominal Capacity (MW) | Combined Import limit into SA (MW) | Combined Export limit out of SA (MW) |
|---|---|---|---|---|
| SA to Queensland | 1450 | 750 | 1300 | 1300 |
| SA to NSW | 370 - 1200 | 300 - 1000 | 800 - 1300 | 900 - 1450 |
| SA to NSW (preferred option) | 920 | 800 | 1300 | 1450 |
| SA to Victoria | 420 | 650 | 1100 | 1200-1350 |

**Notes**

1. Combined limits are the total allowed power transfer across the Heywood interconnector and the new interconnector
2. Combined capacity is lower than aggregate of the two interconnector capacities
3. Export capability is generally higher than import, as it is easier to manage

# Technical assessment considerations

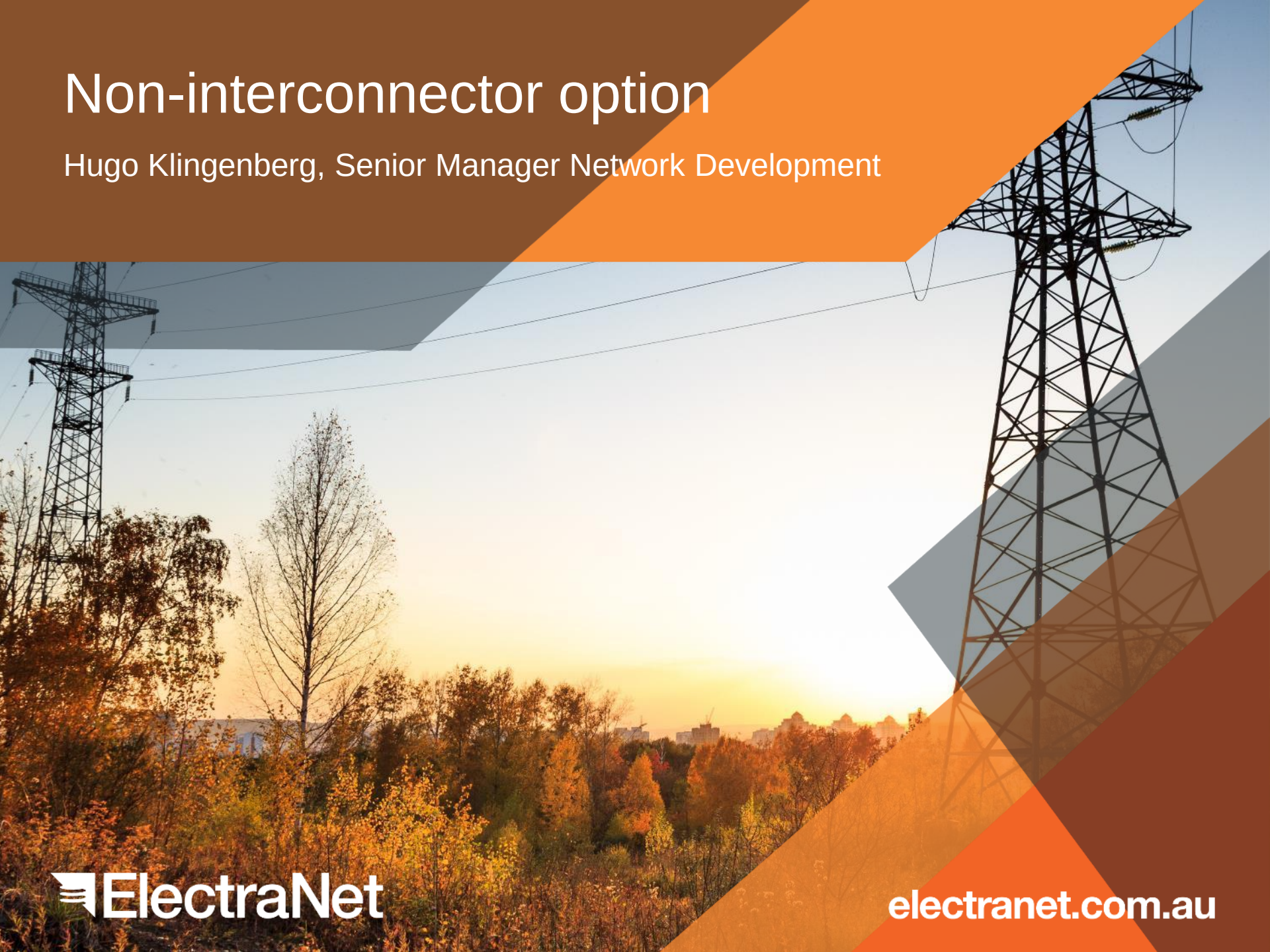
- Technical characteristics of each interconnector option considered – for example fast frequency response and reactive capability of HVDC options and their contribution to improving power system stability
- Surviving loss of the Heywood or new interconnector – special protection scheme developed that responds to such events
- Determining quantum of load shedding and other action (e.g. battery response) needed for responding to major system events
- Base case assumptions in relation to system strength
- Maximise capability – reactive plant needed to manage voltage stability, to ensure options can provide transfer up to higher transient or thermal limits
- Synchronous condensers compared to other dynamic reactive plant
- Power sharing – controllability of the new interconnector
- Transient stability – Enhancement alternatives

# Next steps

- Optimise scope of the preferred solution:
  - Based on feedback
  - Implication of series compensation for future connectivity (line cut-in)
  - Explore opportunities to enhance transfer capabilities further (to deliver greater value)
  - Further develop scope of the special protection scheme
- Other options will be further optimised if new information comes to light that could change the relative ranking of options
- Review system strength requirements in line with new rules and guidelines and whether there is value in providing additional system strength to ensure that existing and new generation is not constrained

# Non-interconnector option

Hugo Klingenberg, Senior Manager Network Development



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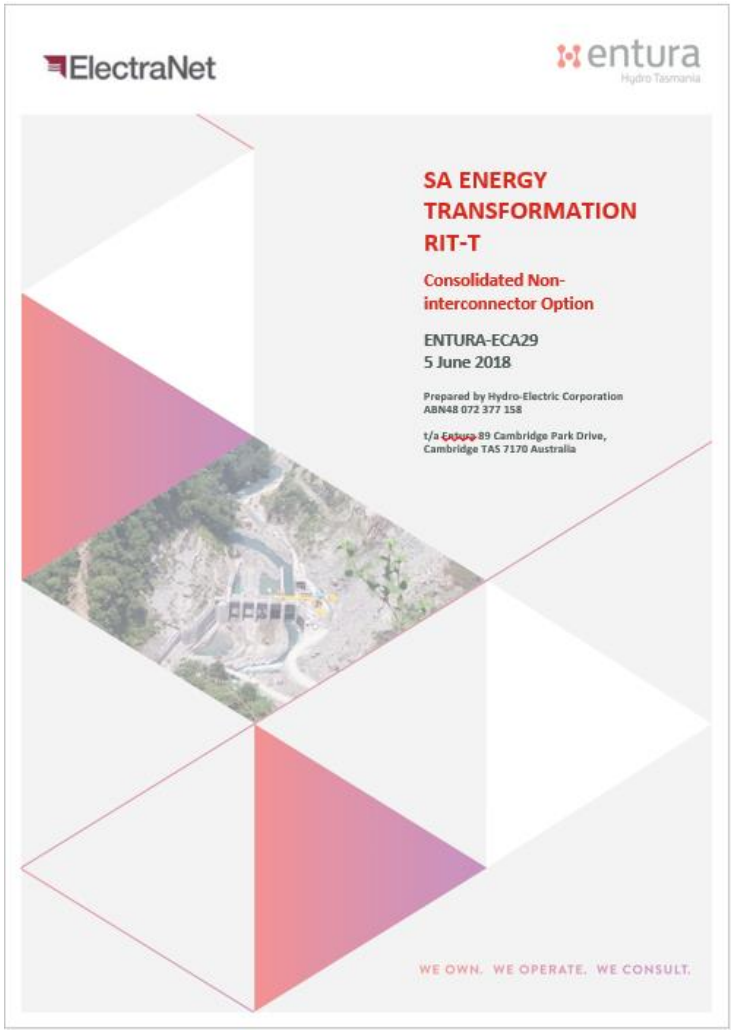
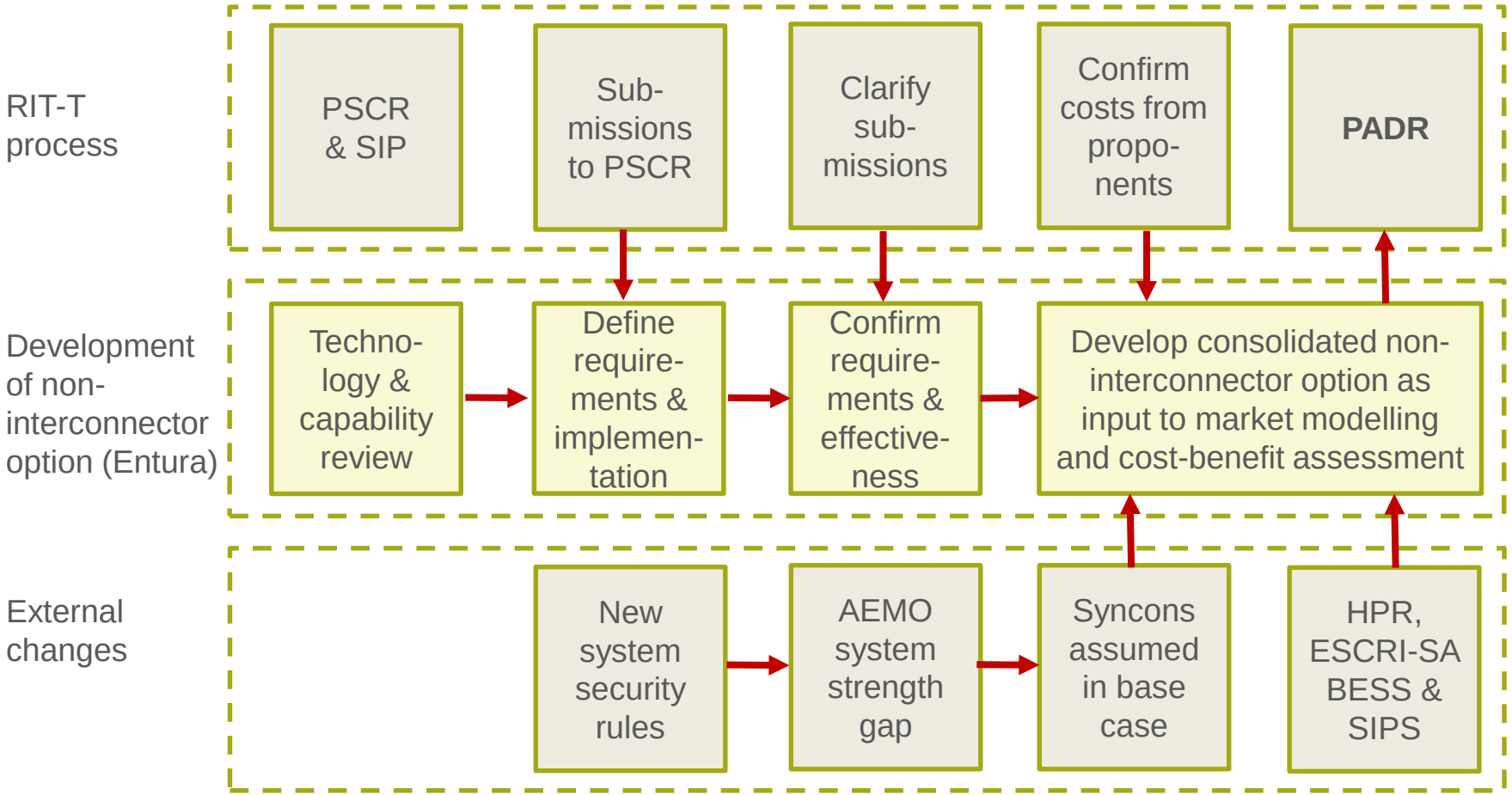
# Approach

- Technical criteria defined in the PSCR and associated supplementary report (SIP)
- Design principles:
  - Same base case for the non-interconnector as well as interconnector options
  - Performance must meet at least the minimum system security requirements
  - Meet preferred system security requirements where cost effective
  - Performance for credible contingencies should be comparable to interconnector options in managing the non-credible loss of the Heywood interconnector
- Considered technical criteria over time frames to: Survive (seconds), Stabilise, Steady (< 1 hour), Sustain (days)




PSCR – Project Specification Consultation Report
SIP – Supplementary Information Paper

# Option development journey




HPR – Hornsdale Power Reserve
BESS – Battery Energy Storage System

PADR – Project Assessment Draft Report
SIPS – System Integrity Protection Scheme



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# Solution options (increasing cost)

| Technology option | Examples |
|---|---|
| Load shedding (at no cost in line with National Electricity Rules) | Under Frequency Load Shedding, Over Frequency Generation Shedding |
| Existing Battery Energy Storage System (BESS) (without additional costs) | System Integrity Protection Scheme, Fast Frequency Response |
| Any committed generation offering relevant service at incremental cost | Solar thermal or pumped hydro energy systems |
| Murraylink control upgrade | |
| Installing additional synchronous condensers | |
| Directing existing generators during system emergencies | In line with AEMO existing practice and costs |
| Contracting existing generators | |
| Installing additional BESS/ generators | |
| Contracted demand response | |

# Consolidated non-interconnector option[1]

| Technology/location | Nameplate | Inertia or Fast Frequency Response (FFR) equivalent | Fast FCAS | System strength |
|---|---|---|---|---|
| Pumped storage – Cultana | 120 MW | 420 MWs | 15 MW | 600 MVA |
| Osborne Cogeneration | 180 MW | 550 MWs | 30 MW | 150 MVA |
| Solar thermal – Davenport | 120 MW | 660 MWs | 60 MW | 600 MVA |
| Battery – Tailem Bend | 150 MW | Expected to exceed 1,000 MWs (FFR) | 75 MW | - |
| Murraylink – Berri | 200 MW | | 40 MW | - |
| Battery – Tailem Bend | 150 MW | Expected to exceed 1,000 MWs (FFR) | 75 MW | - |
| Minimum load control | | | | |

1. Developed by Entura

# Solution has to work for multiple time frames

| Survive | Stabilise | Steady | Sustain |
|---|---|---|---|
| 0 seconds to 10 seconds | 10 seconds to 30 minutes | 30 minutes to 1 hour | 1 hour to 7 days |
| *Example response sources:*<br>• *Inertia/ system strength sources including online synchronous plant response*<br>• *Battery response*<br>• *Other frequency response (e.g. an upgraded MurrayLink)*<br>• *Load shedding and demand response* | *Example response sources:*<br>• *Inertia/ system strength sources including online synchronous plant response*<br>• *Battery response*<br>• *Other frequency response (e.g. an upgraded MurrayLink)*<br>• *Fast start plant*<br>• *Additional load shedding and demand response as required* | *Example response sources:*<br>• *Inertia/ system strength sources*<br>• *Other frequency response (e.g. an upgraded MurrayLink)*<br>• *Peaking and other fast start plant dispatched as required*<br>• *Demand response* | *Example response sources:*<br>• *Inertia/ system strength sources*<br>• *Other frequency response (e.g. an upgraded MurrayLink)*<br>• *Base and intermediate generators (cold start)*<br>• *Other plant dispatched as required*<br>• *Special purpose demand response* |



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# Key conclusions

- Although the non-interconnector option is technically viable, it does not provide the same system security benefits as a second interconnector
- The non-interconnector solution also poses additional risks:
  - Although gas fired power stations may not remain economically viable, it is assumed that the current fleet (or equivalent) will remain available for the planning horizon of this study
  - The continued growth in rooftop PV installations is leading to the minimum grid demand approaching zero in the mid-2020s – future rooftop PV installations will have to be controllable in order to disconnect them under certain operating conditions when operating as an island – this challenge will be exacerbated without timely new interconnector development

# Market benefits assessment

Brad Harrison, Principal Energy Market Analyst

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# Market benefits and the RIT-T




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# Market benefits and the RIT-T

- Categories of market benefits considered
  - Avoided fuel costs (first order)
  - Avoided generator and storage capital expenditure (second order)
  - Avoided transmission network capital expenditure (Renewable Energy Zone) (second order)
  - Avoided transmission network capital expenditure (Committed project)
  - Avoided generator fixed costs (second order)
  - Avoided voluntary load curtailment
  - Avoided unserved energy (involuntary load curtailment)
  - Renewable Energy Target penalty

# Scenarios

| Variable | High | Central | Low |
|---|---|---|---|
| **Weighting** | 25% | 50% | 25% |
| **Electricity demand**<br>**(including impact from distributed energy resources)** | AEMO 2018 EFI **strong** demand forecasts plus potential SA spot load development of **345 MW** | AEMO 2018 EFI **Neutral** demand forecasts | AEMO 2018 EFI **Weak** demand forecasts |
| **Gas prices – long term** | **$11.87 GJ in Adelaide**<br>($1.68/GJ higher than the AEMO ISP strong forecast) | **$ 8.40/GJ**<br>(AEMO 2017 GSOO Neutral forecast; $0.77 lower than AEMO ISP Neutral forecast) | **$7.40/GJ**<br>($0.62/GJ lower than the AEMO ISP weak forecast) |
| **Emission reduction renewables policy – in addition to Renewable Energy Target (RET)** | Emissions reduction around **45%** from 2005 by 2030 (Federal opposition policy) | Emissions reduction around **28%** from 2005 by 2030 (Federal Government policy) | **No** explicit emission reduction beyond current RET |
| **Jurisdictional emissions targets** | VRET 25% by 2020 and **40% by 2025**<br>QRET **50% by 2030** | VRET 25% by 2020 and **40% by 2025**<br>QRET **50% by 2030** | VRET 25% by 2020 and **40% by 2025**<br>QRET **50% by 2030** |
| **SA inertia requirement – RoCoF limit for non-credible loss of Heywood Interconnector** | **1 Hz/s** (International standard) | **3 Hz/s** (current SA Government requirement) | **3 Hz/s** (current SA Government requirement) |
| **Capital costs** | **15%** higher than central scenario | AEMO **2016 NTNDP** with some updates from **2018 ISP**. | **15%** lower than central scenario |

# Approach

- Simplifications were required and where made these have tended to reduce benefits
- These include…
  - Least cost ‘linear’ generator expansion
  - Security constrained economic dispatch
  - Hourly dispatch (not five minutes)
  - 50% Probability of Exceedance (POE) Demand
  - Average heat rates
  - Minimum generation up and down times to manage dispatch inflexibilities

# System strength

- Current arrangement
  - Synchronous floor

    AEMO constrains on or directs synchronous generators to meet the minimum system strength requirement
  - Low non-synchronous cap

    If the synchronous floor is met but not exceeded, a low cap is applied to non-synchronous generator output in SA
  - High non-synchronous cap

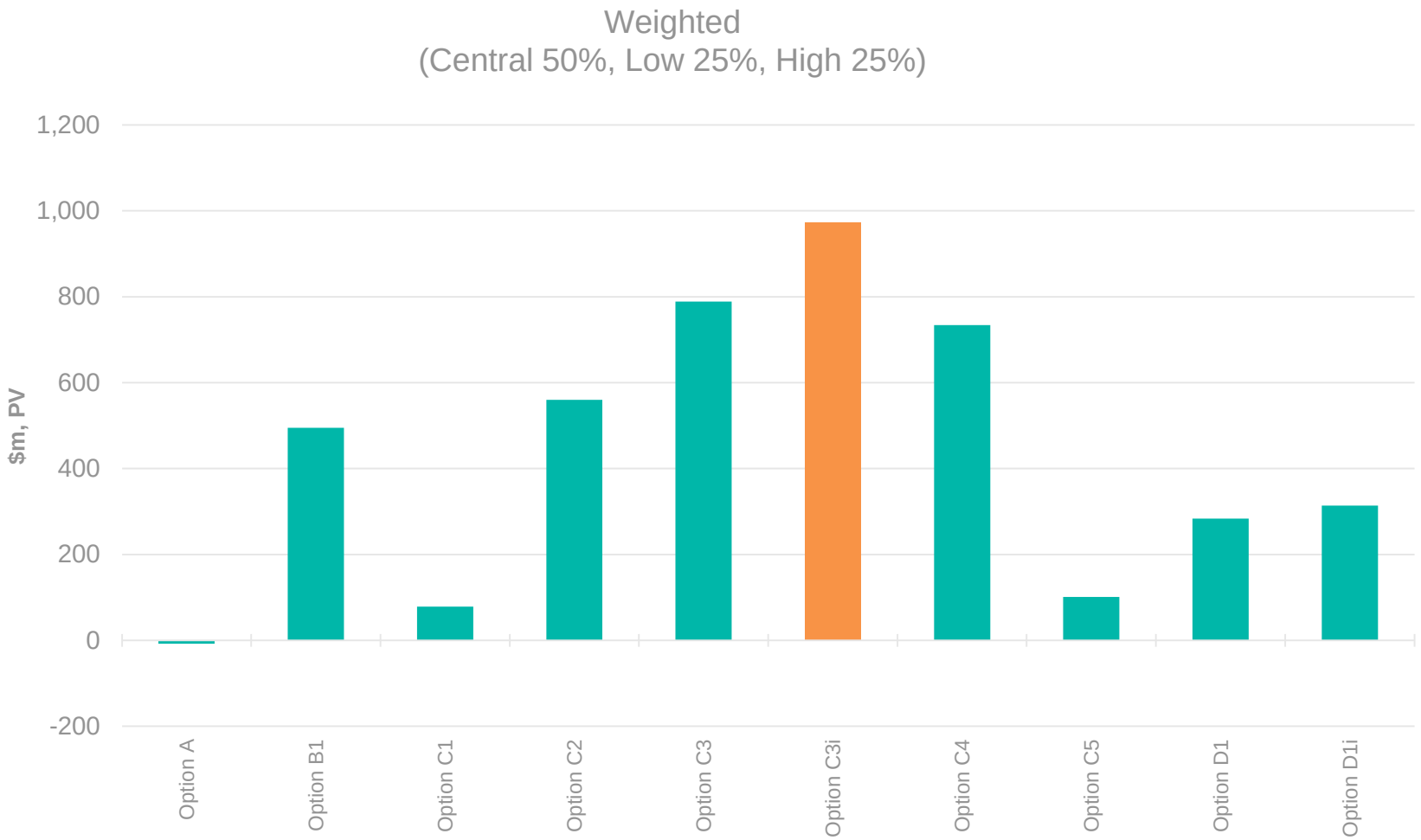
    If the synchronous floor is met and exceeded, a high cap is applied to non-synchronous generator output in SA
- Base case assumptions
  - High non-synchronous cap
  - 2,400 MWs of inertia is provided by synchronous condensers

# Options considered

| Option | Description | Capital Cost ($2018 billion) |
|---|---|---|
| Option A | Non-interconnector | $0.13[1] |
| Option B | Qld HVDC | $1.8 |
| Option C1 | NSW HVDC | $0.8 |
| Option C2 | NSW 275 kV | $1.0 |
| Option C3 | NSW 330 kV via Buronga | $1.4 |
| **Option C3i** | **C3 + series compensation** | **$1.5** (NPV ~$0.9) |
| Option C4 | NSW 330 kV Buronga by pass | $1.3 |
| Option C5 | NSW 500 kV | $2.9 |
| Option D1 | Victoria 275 kV | $1.2 |
| Option D1i | D1 + series compensation | $1.2 |

Note 1: Per annum opex cost

# Weighted net market benefits



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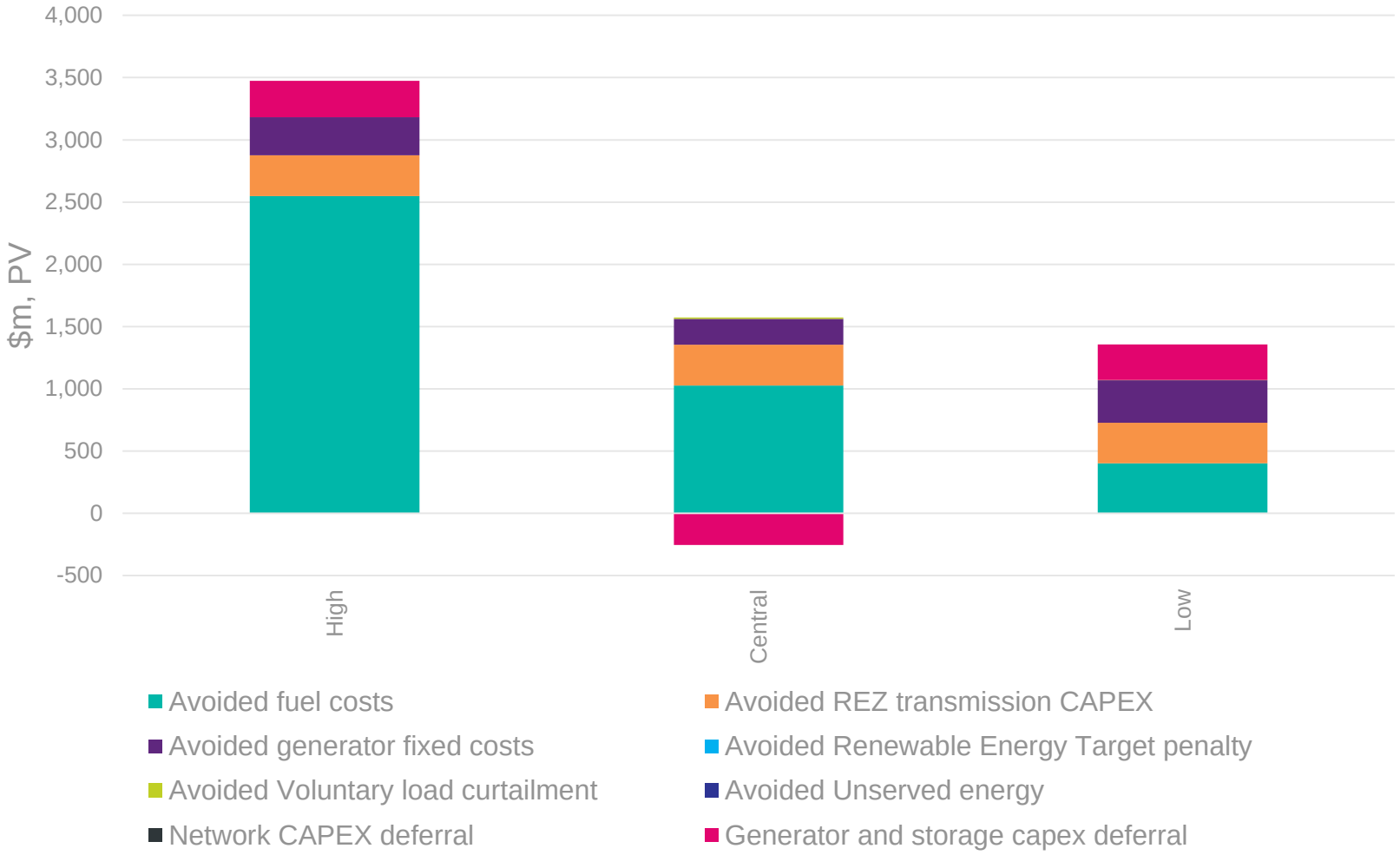
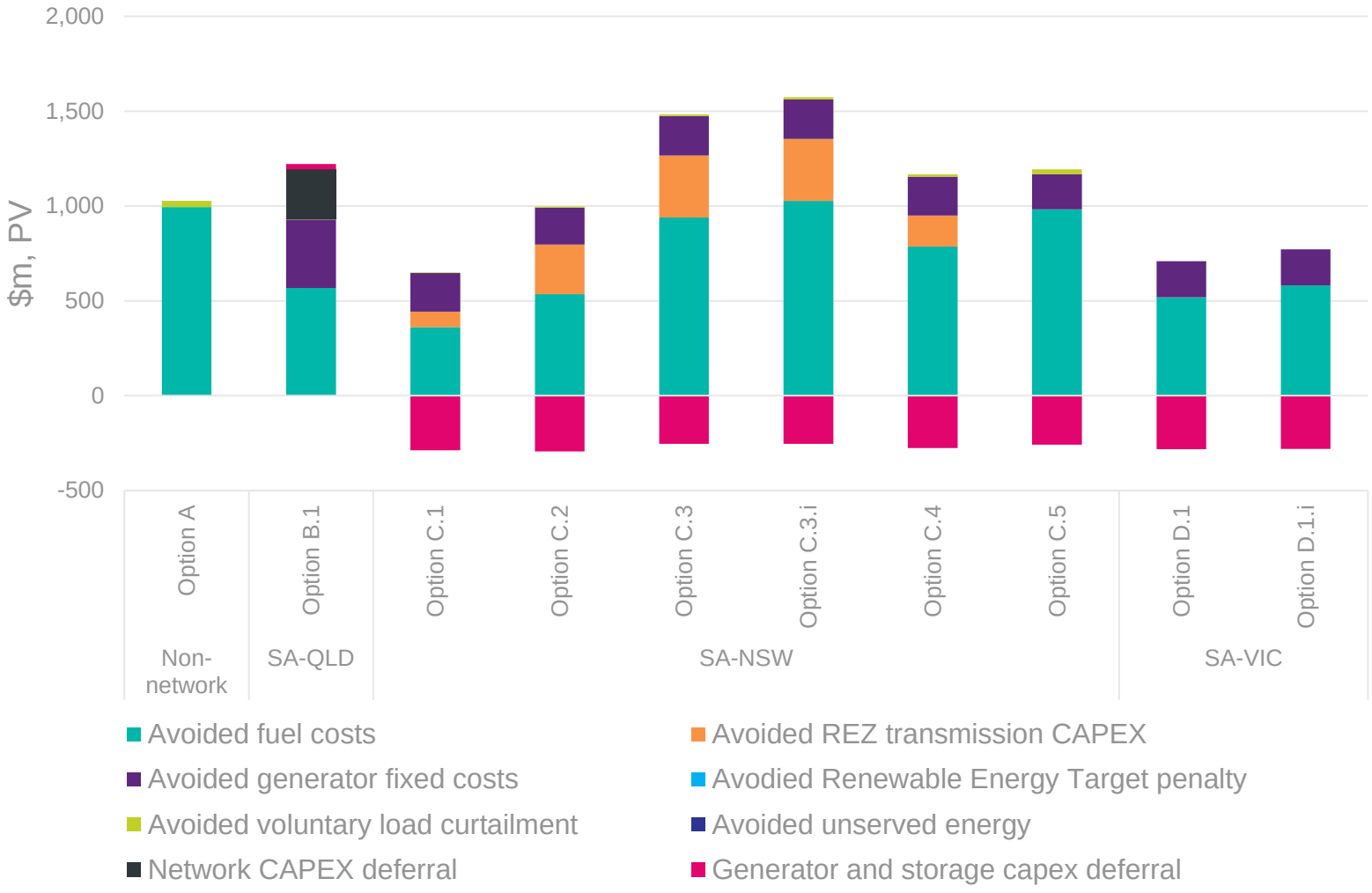
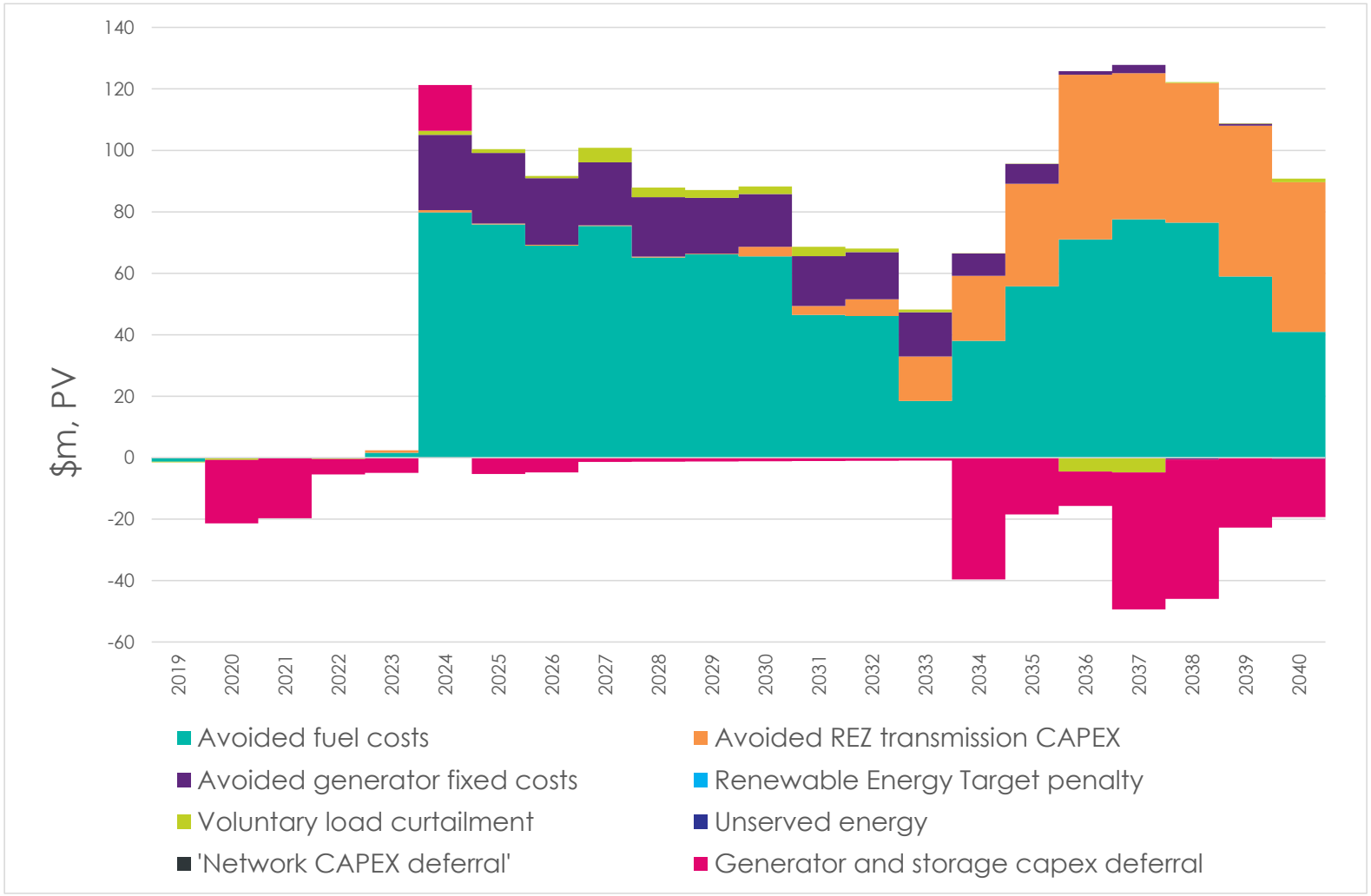
# Gross market benefits – preferred option



# Central scenario – gross market benefits



# Central – preferred option – gross benefits



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# Low scenario – gross market benefits




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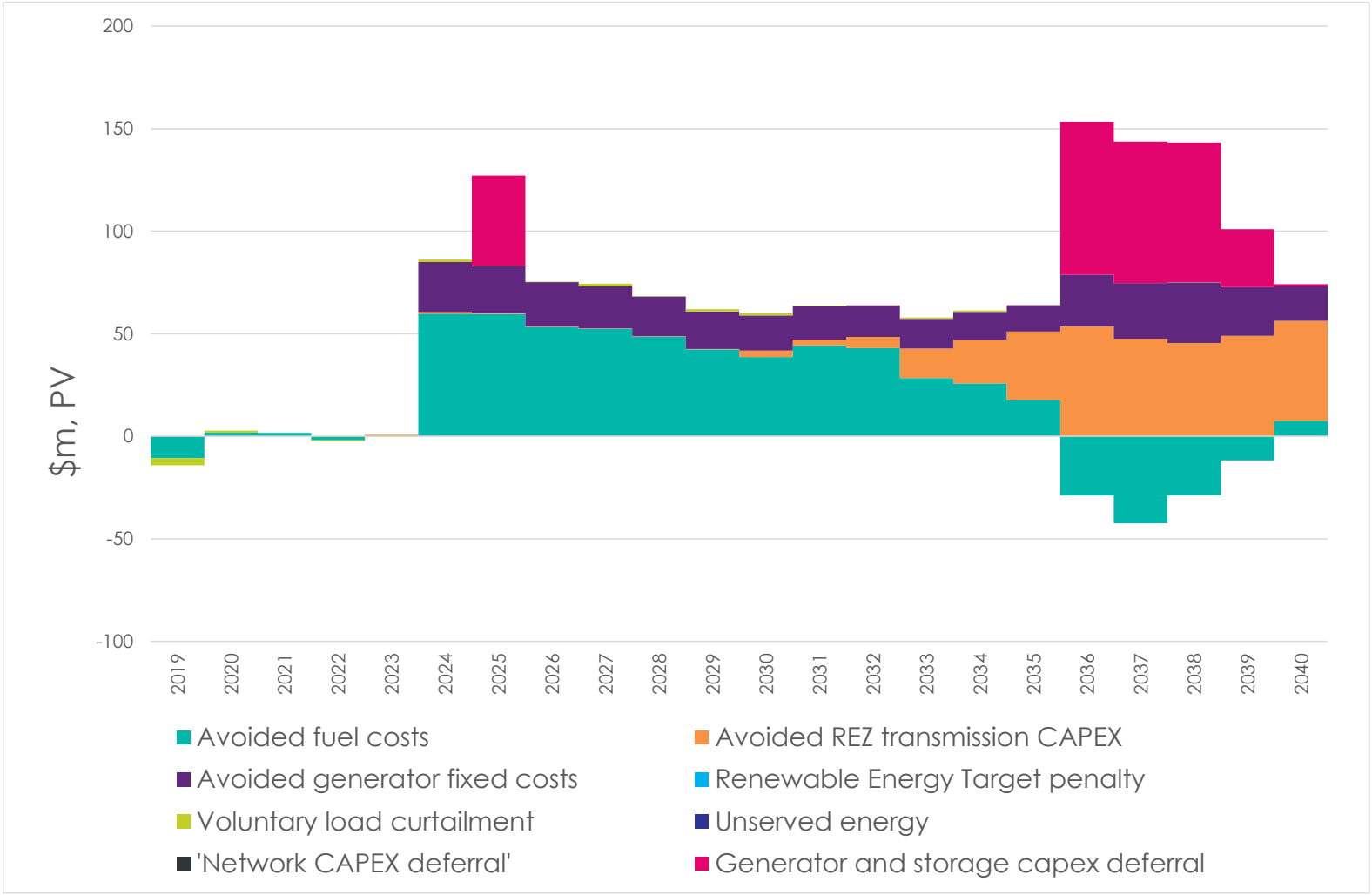
# Low – preferred option – gross benefits



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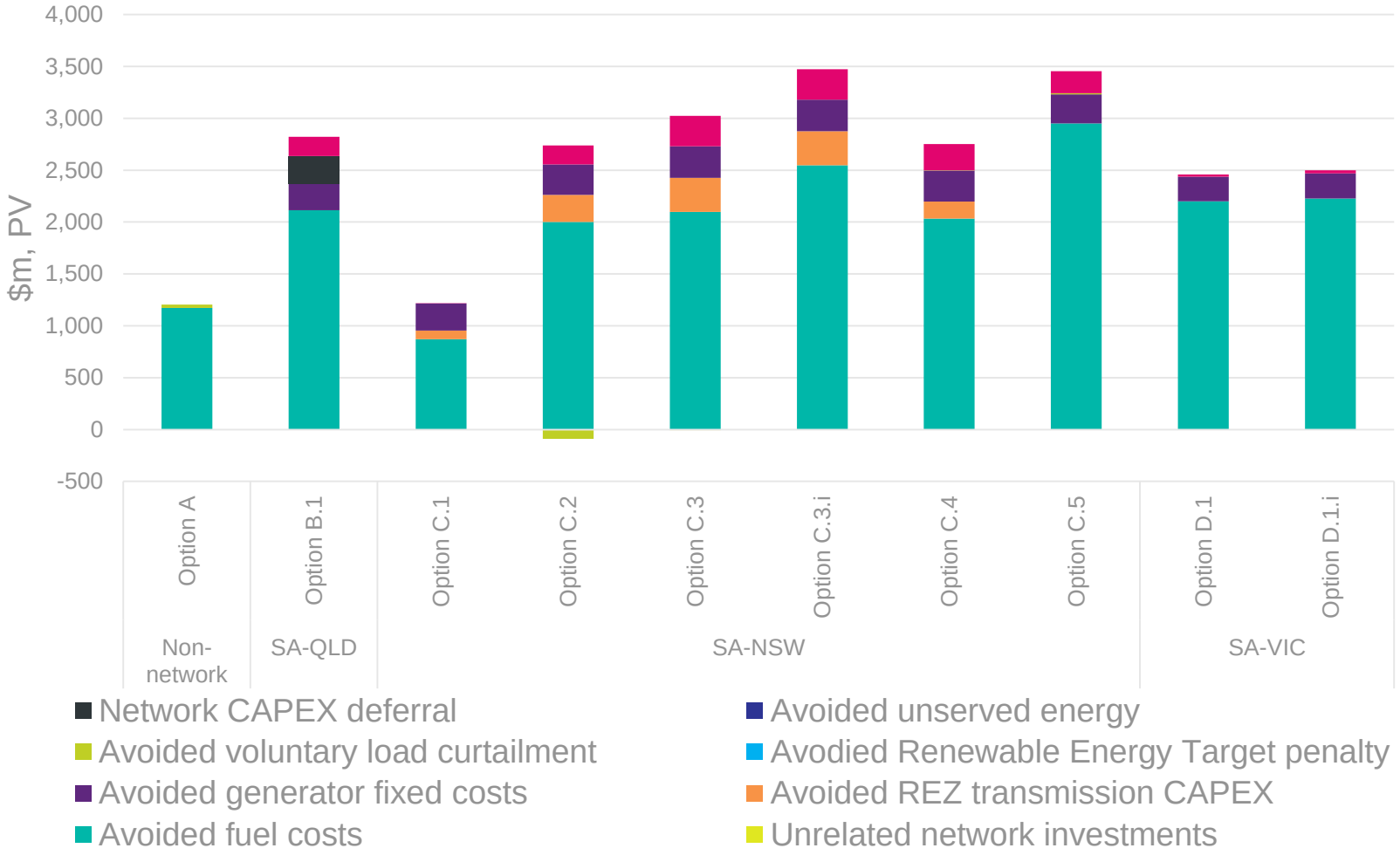
# High scenario – gross market benefits



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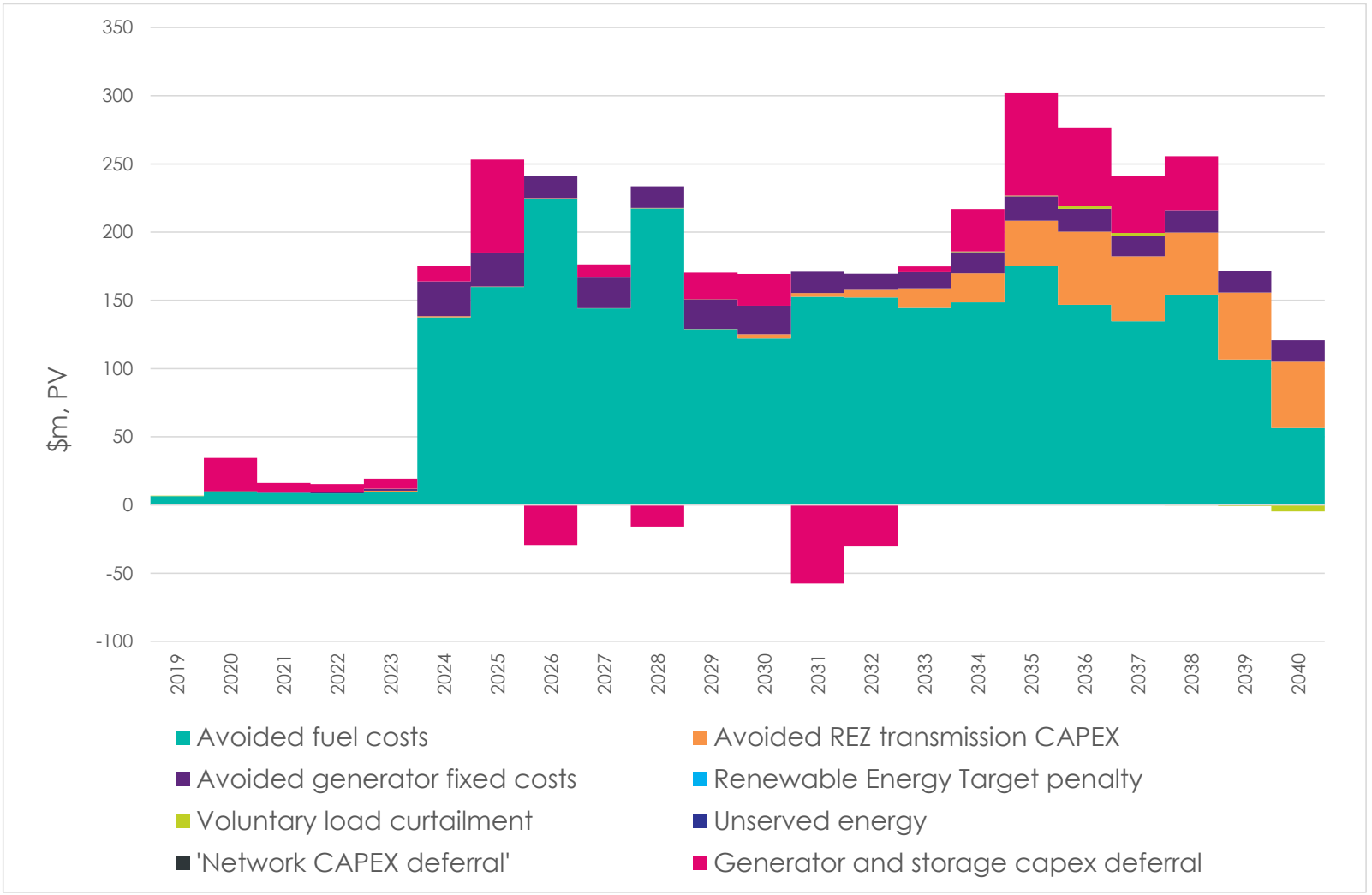
# High – preferred option – gross benefits



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# Sensitivities

| Option | Description | Benefit Impact |
|---|---|---|
| Eyre Peninsula | Central demand with SA load increased by 345 MW mining load | Up |
| High gas | High scenario gas price of $11.87/GJ applied to the central scenario | Up |
| Increased role for gas | Gas price of $5.91/GJ applied to central scenario | Down |
| RoCoF 1 Hz/s | More onerous RoCoF limit applied to the central scenario | Up |
| 45% emission reduction | More onerous emissions reduction applied to central scenario | Up |
| Virtual Power Plant | 450 MW virtual power plant assumed from 2020 in metro Adelaide | Down |
| Coal prices | Cost of black coal across the eastern seaboard increased by 30 per cent. | Down |
| Heywood declared protected | Loss of Heywood interconnector declared a credible event. Heywood limited to 250 MW in the base case. | Up |

**The preferred option remains the preferred option and delivers positive net market benefits under all sensitivities tested**

# Sensitivities




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# Next steps

- Further alignment with ISP input assumptions
  - Wider gas spread will be retained
- AEMO Electricity Statement of Opportunities (ESOO) update expected in late August
  - Consider the potential impact of any new information
- Deep dive modelling workshop in mid-August to help inform submissions
  - Please register your desire to attend – we will send an invitation
  - Nominate any issues you would like covered

# AEMO Integrated System Plan

Elijah Pack, Manager National Planning, AEMO

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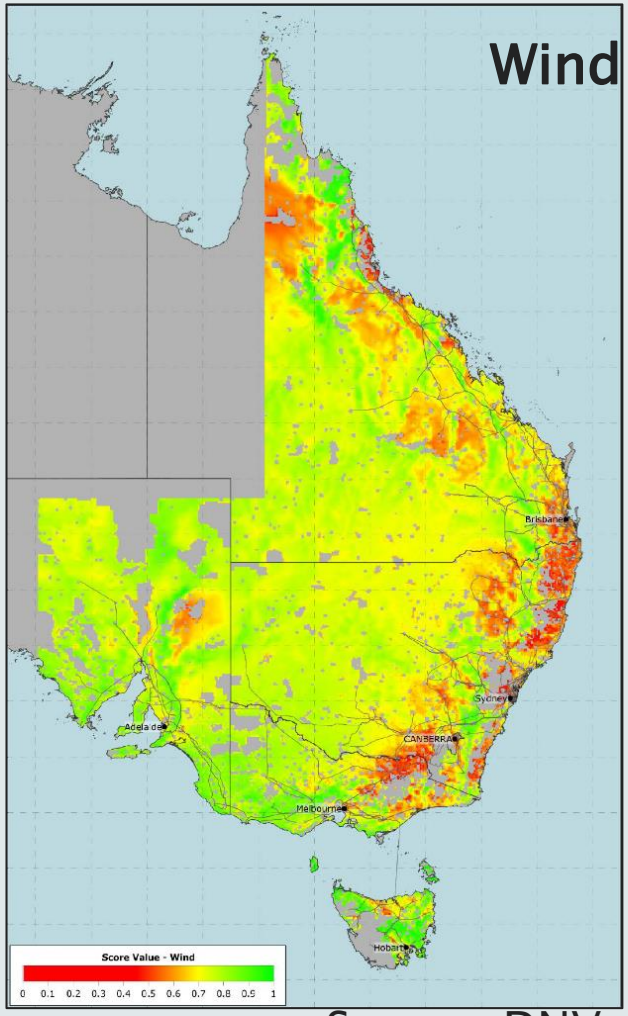
# Context

- The National Electricity Law establishes AEMO as the national transmission planner, requiring AEMO to:
  - develop a National Transmission Network Development Plan
  - provide advice on the development of the grid or projects that could affect the grid;
  - provide a national strategic perspective for transmission planning and coordination;

- The Finkel review recommended AEMO develop and *Integrated Grid Plan* as part of *Better system planning,* one of the pillars to deliver the key outcomes.

# Renewable Energy Zone (REZ) Candidate Identification

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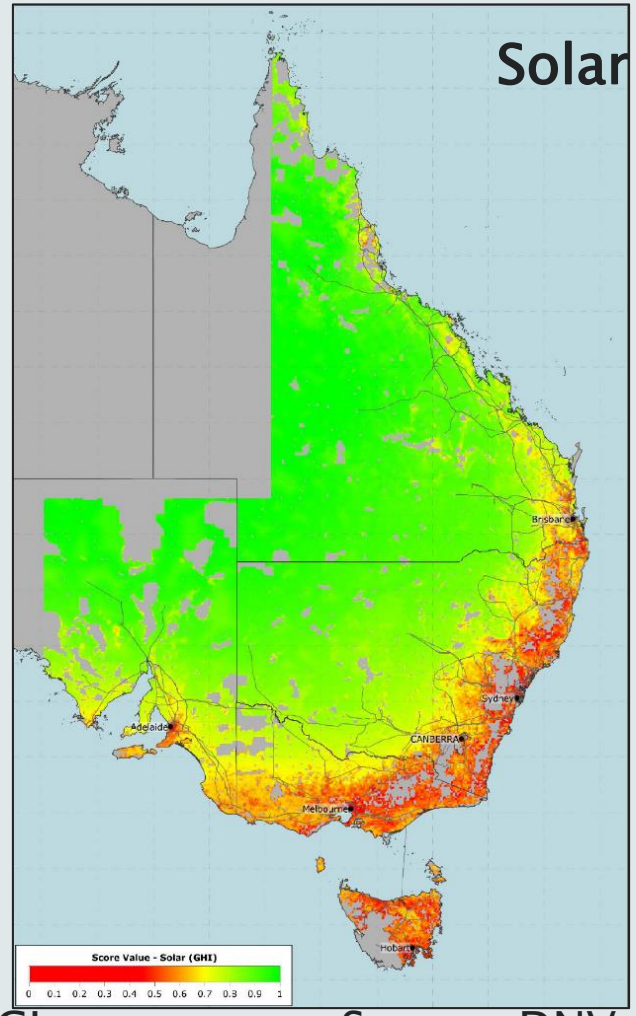


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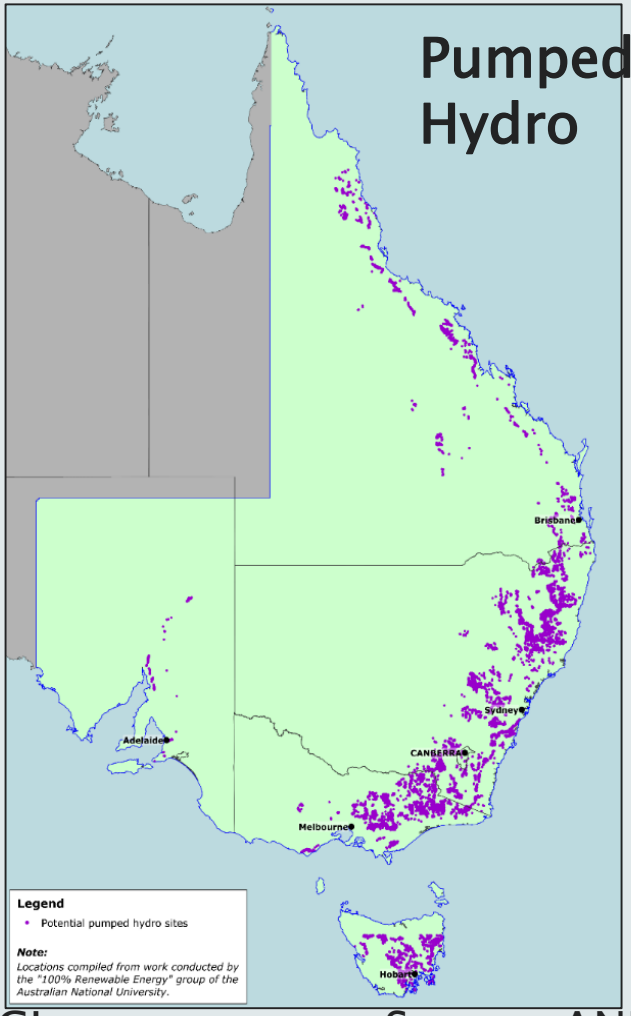
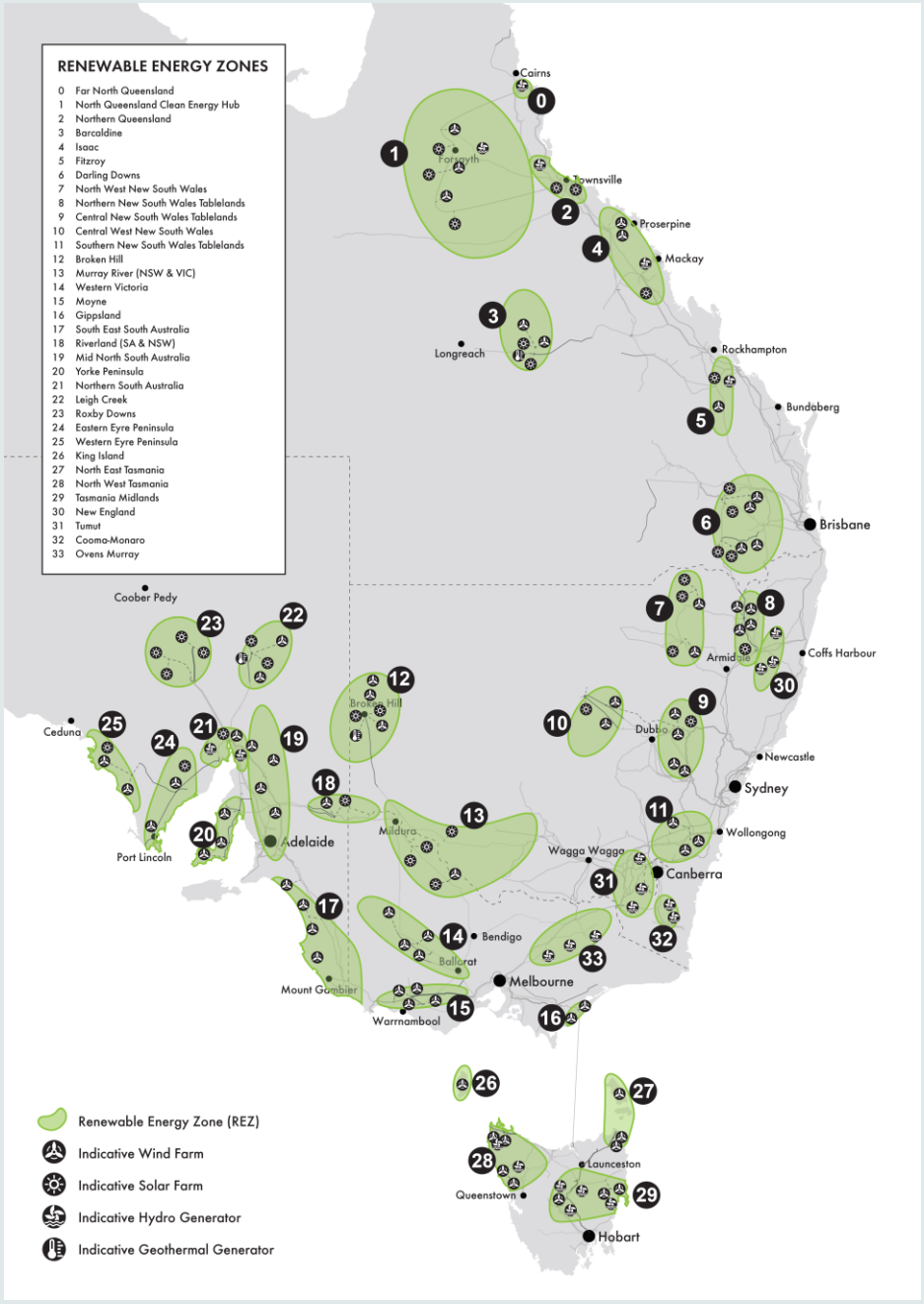



Source: ANU

# REZ Candidates



# Key inputs

**Resource Quality**

- Wind and solar resource data from DNV-GL

*Benchmarked against existing projects to validate*

**Technology**

- Technology costs and forward projection of costs primarily from CSIRO – confirmed by AEMO work and stakeholder consultation
- Pumped storage costs from ANU study
- Gas prices from Core Energy adjusted in early years to market prices
- Coal prices from Wood McKenzie

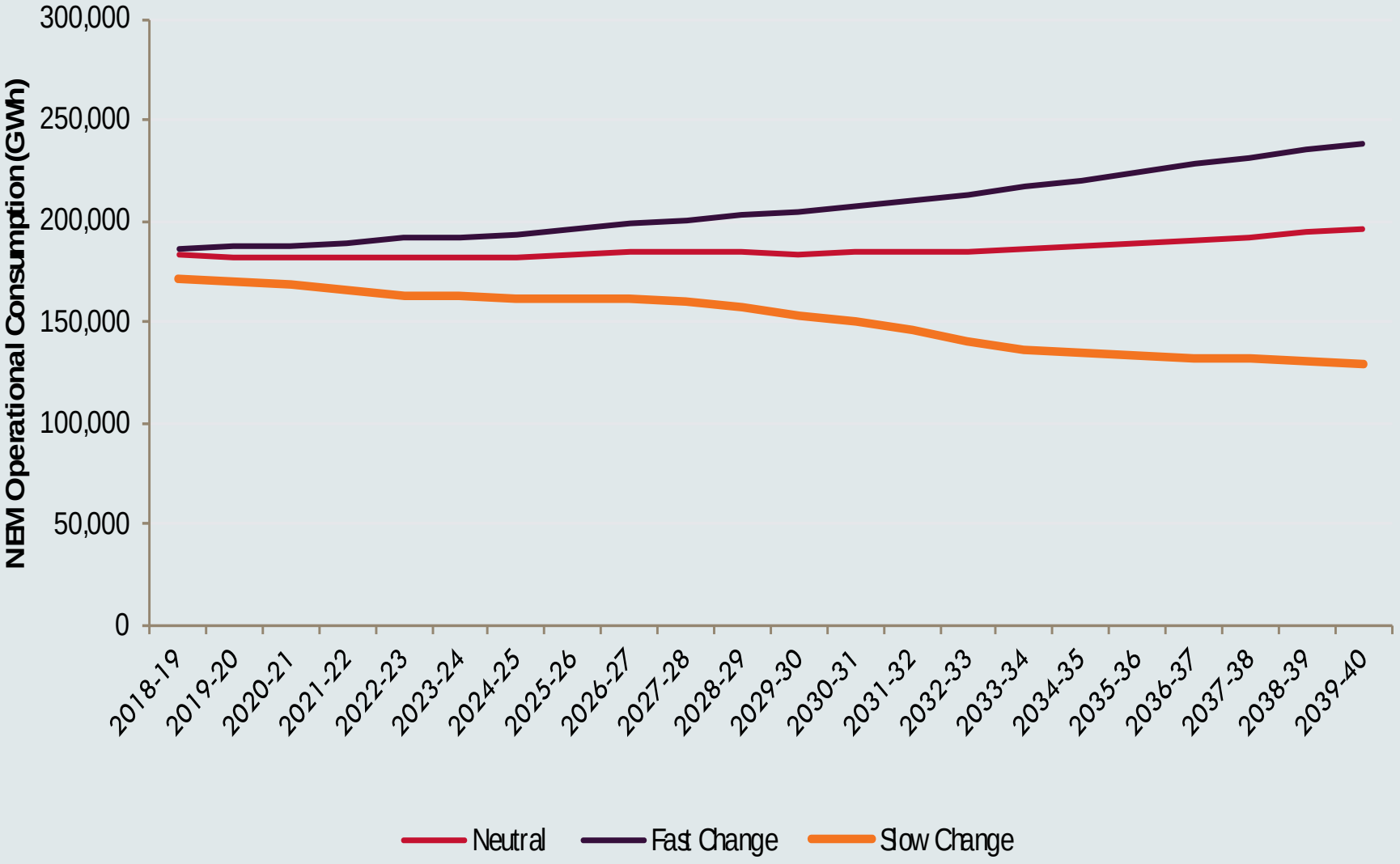
*Price relativities appear consistent with observed behaviour and investor interest*

# Scenarios and sensitivities

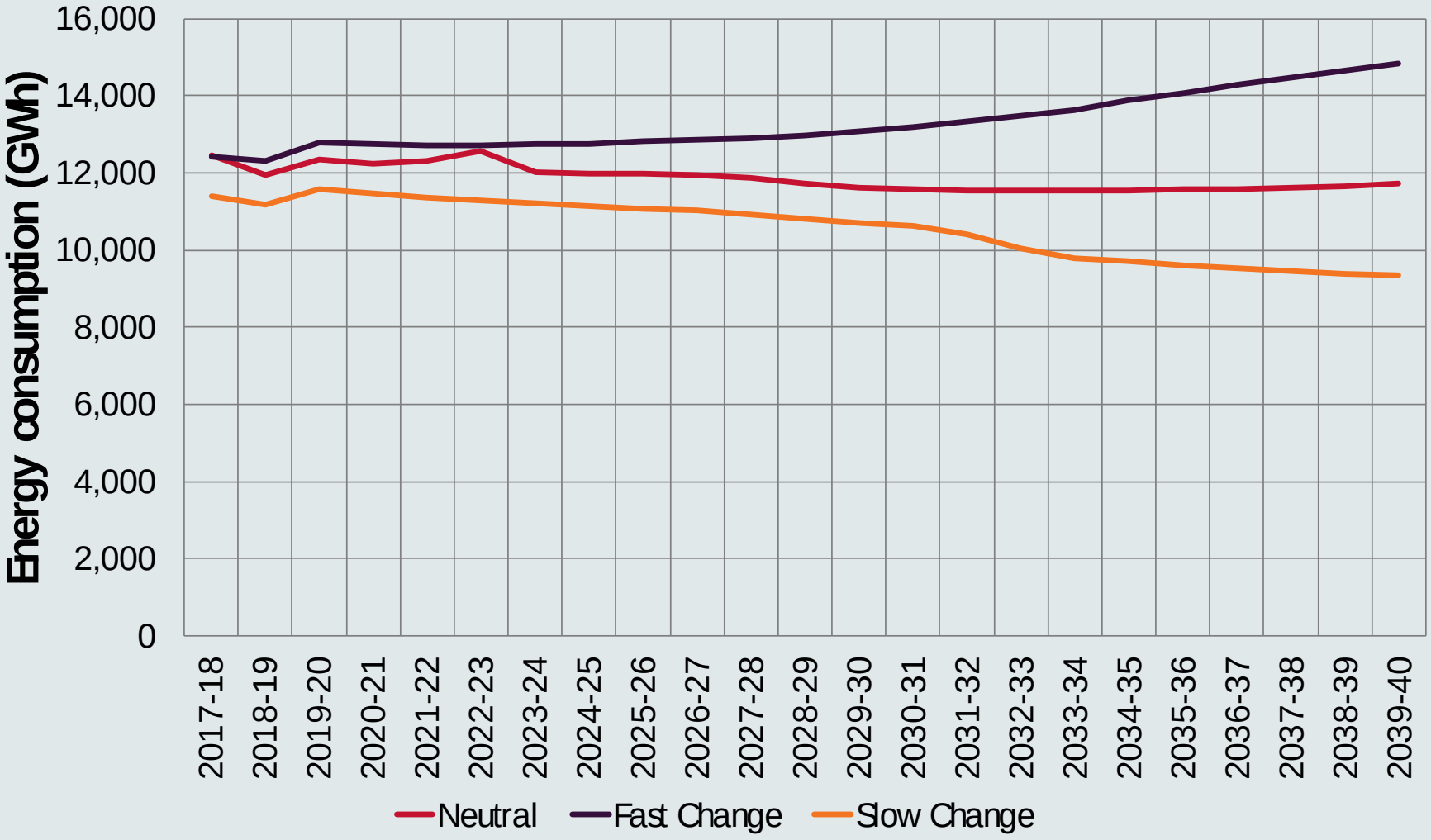
The ISP focuses on seven scenarios/sensitivities:

- **Two base cases**:
  - Neutral, and Neutral with storage initiatives.
- **Three additional scenarios**:
  - Slow change, Fast change, and High DER.
- **Two additional sensitivities** to explore key opportunities or risks:
  - Increased role for gas, and Early exit of coal-fired generation.

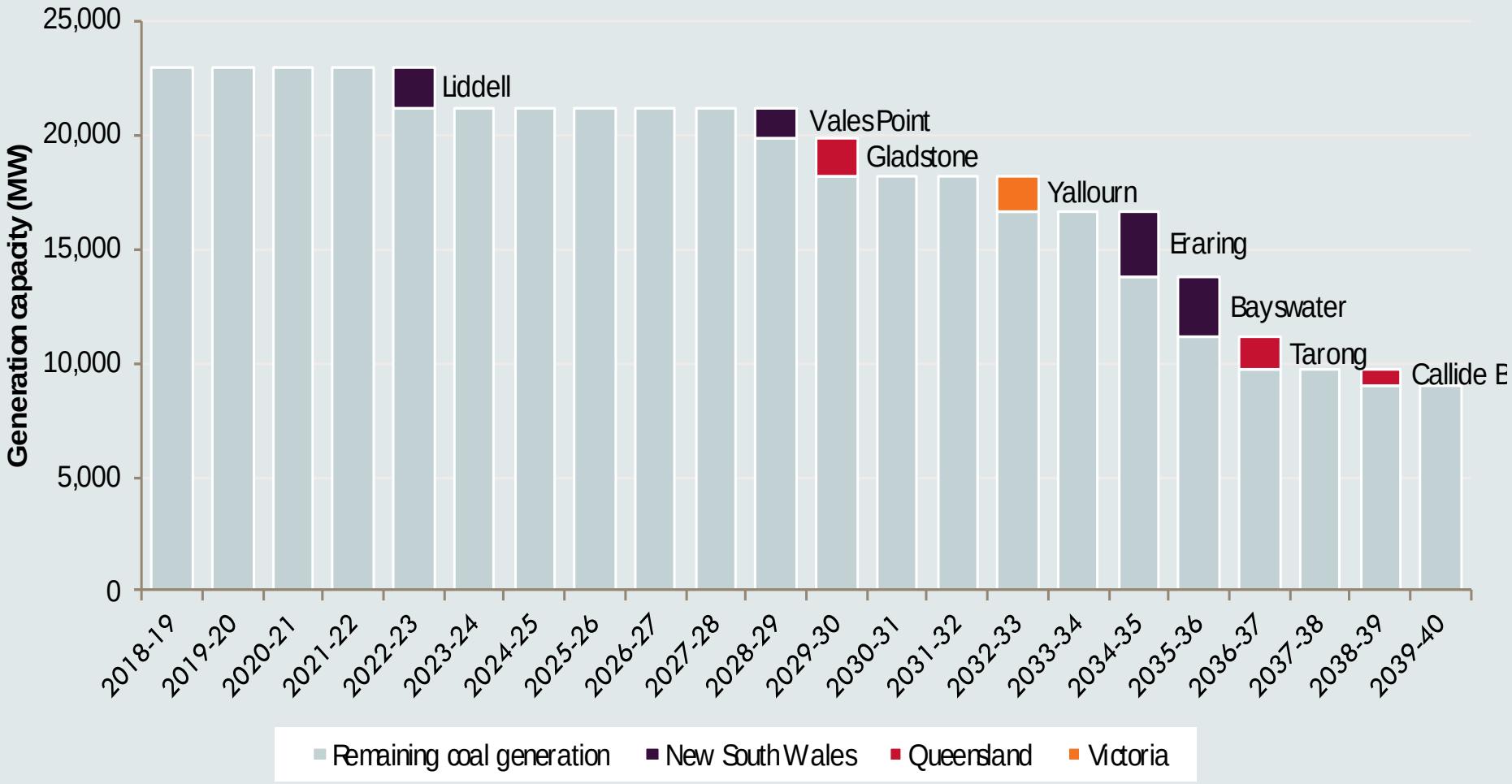
# Key Inputs – NEM Energy Consumption



# Key Inputs – SA Energy Consumption



# Key Inputs – Coal fleet operating life

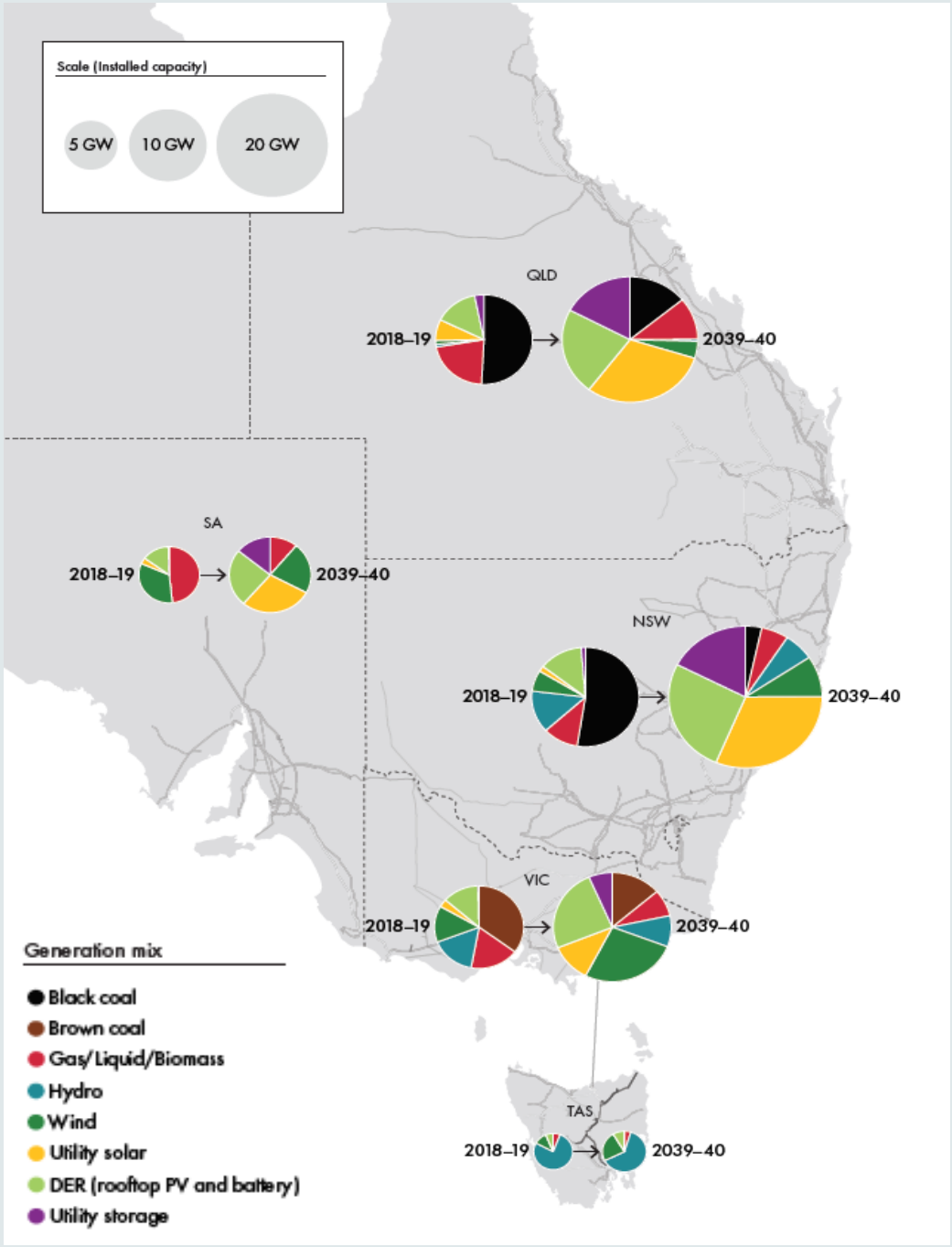


# A few key insights

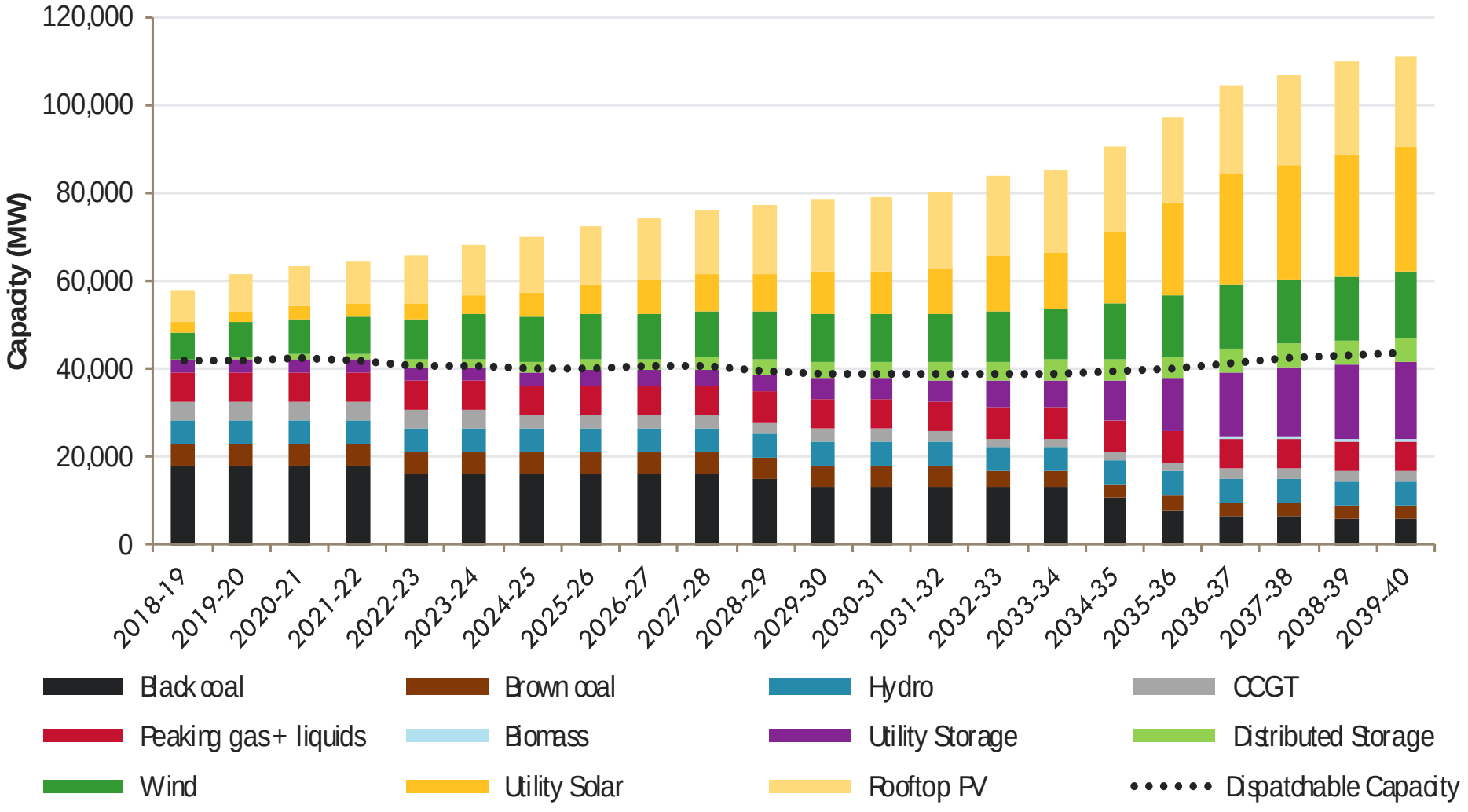
- Economic growth and population growth are counterbalanced by energy efficiency and distributed energy resources.
- Maintaining existing coal-fired generation up to the end of its technical life is a key element of a least-cost approach.
- A portfolio approach to replacing thermal generation:
  - Utility-scale renewable generation, energy storage, distributed energy resources (DER), flexible thermal capacity including gas-powered generation (GPG), and transmission.
- The crucial role of transmission to connect geographically dispersed renewable generation, establish REZs, and share surplus energy across the NEM
- DER can greatly reduce the total cost of supply, and will benefit from more interconnection.
- Focus on event-based timing and managing risks of unplanned events.

# Projected change in resource mix

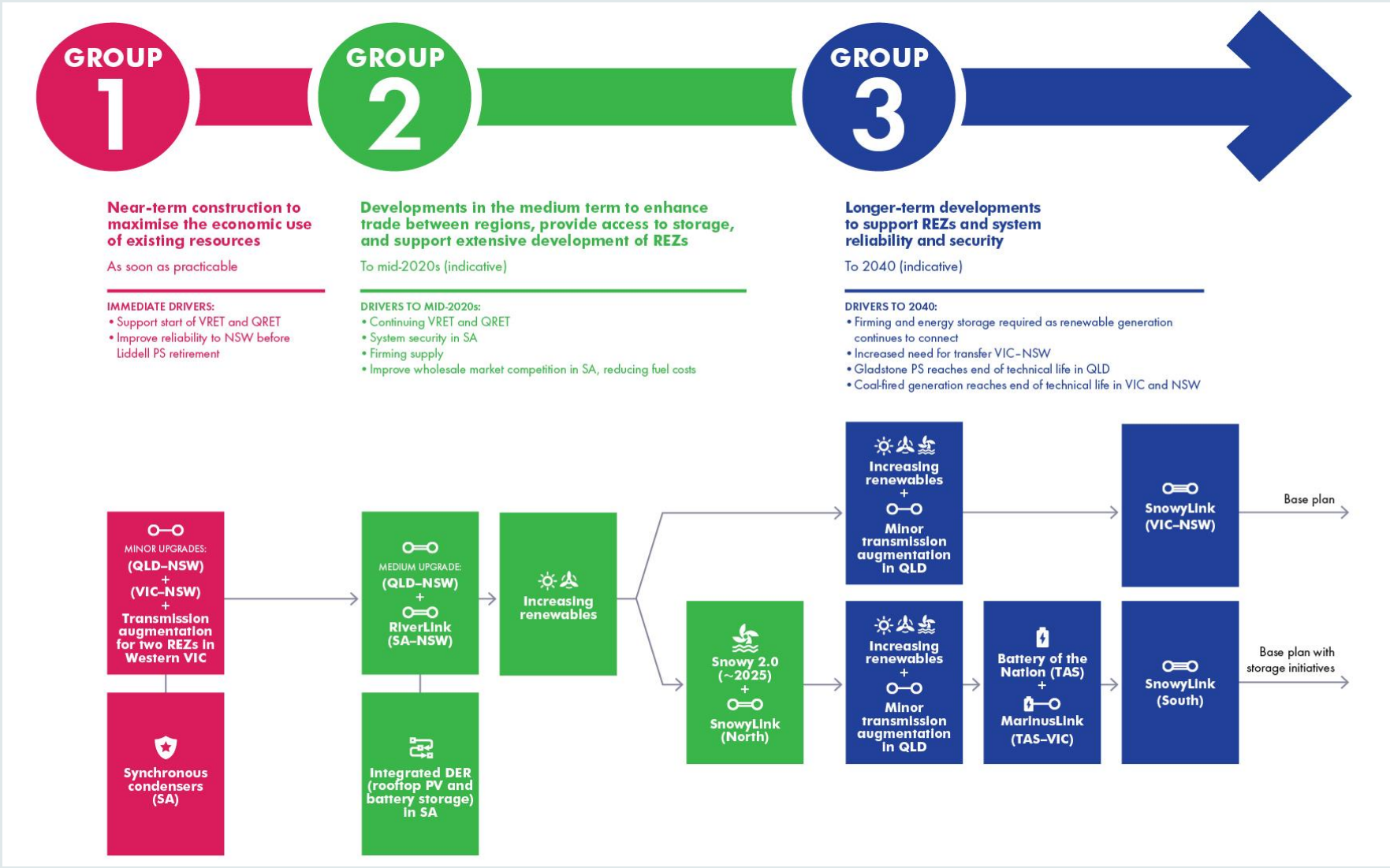
Installed capacity by NEM region over the 20-year plan horizon



# NEM Energy Outlook (Results)



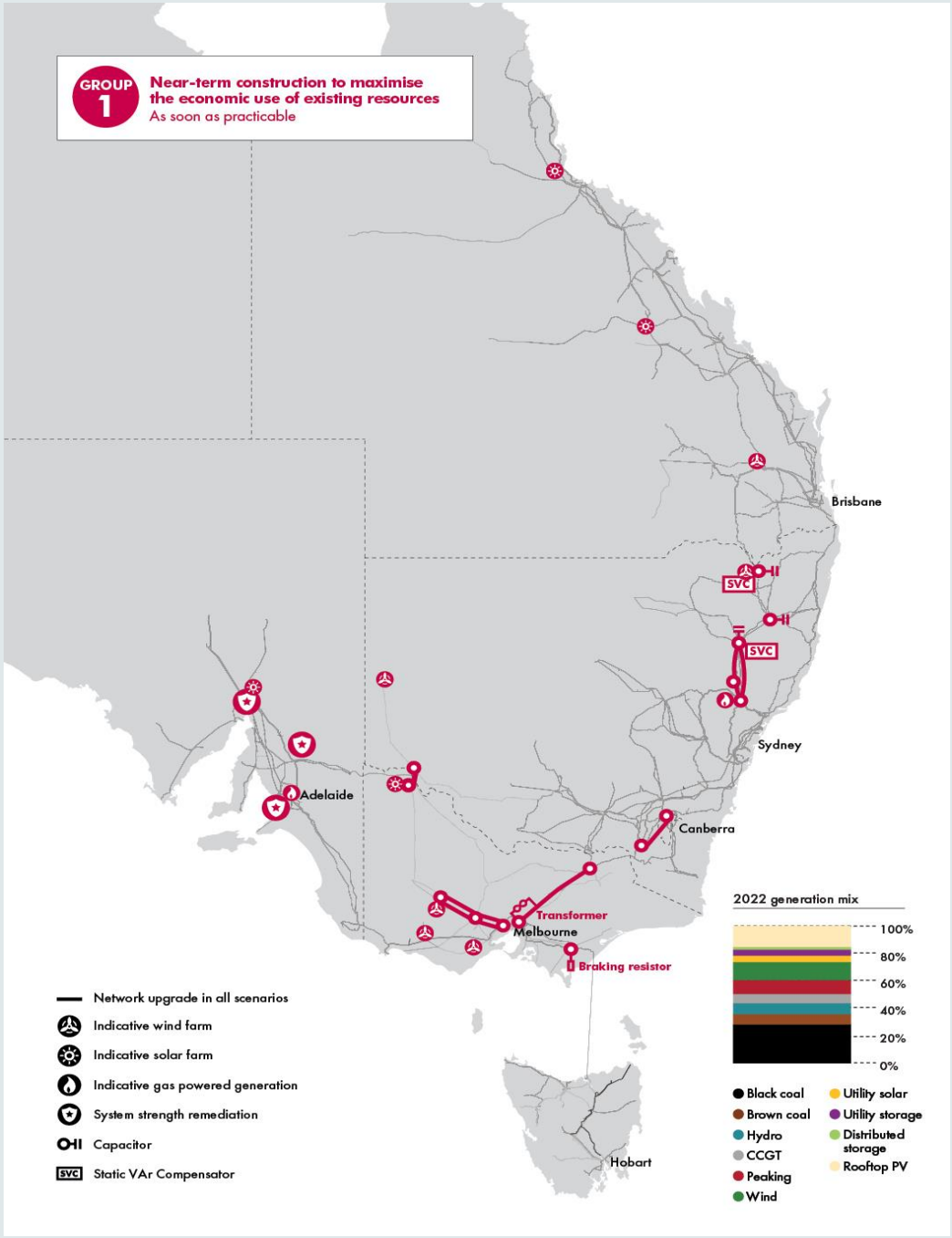
# 20 year integrated development plan



# Group 1

## Near-term construction

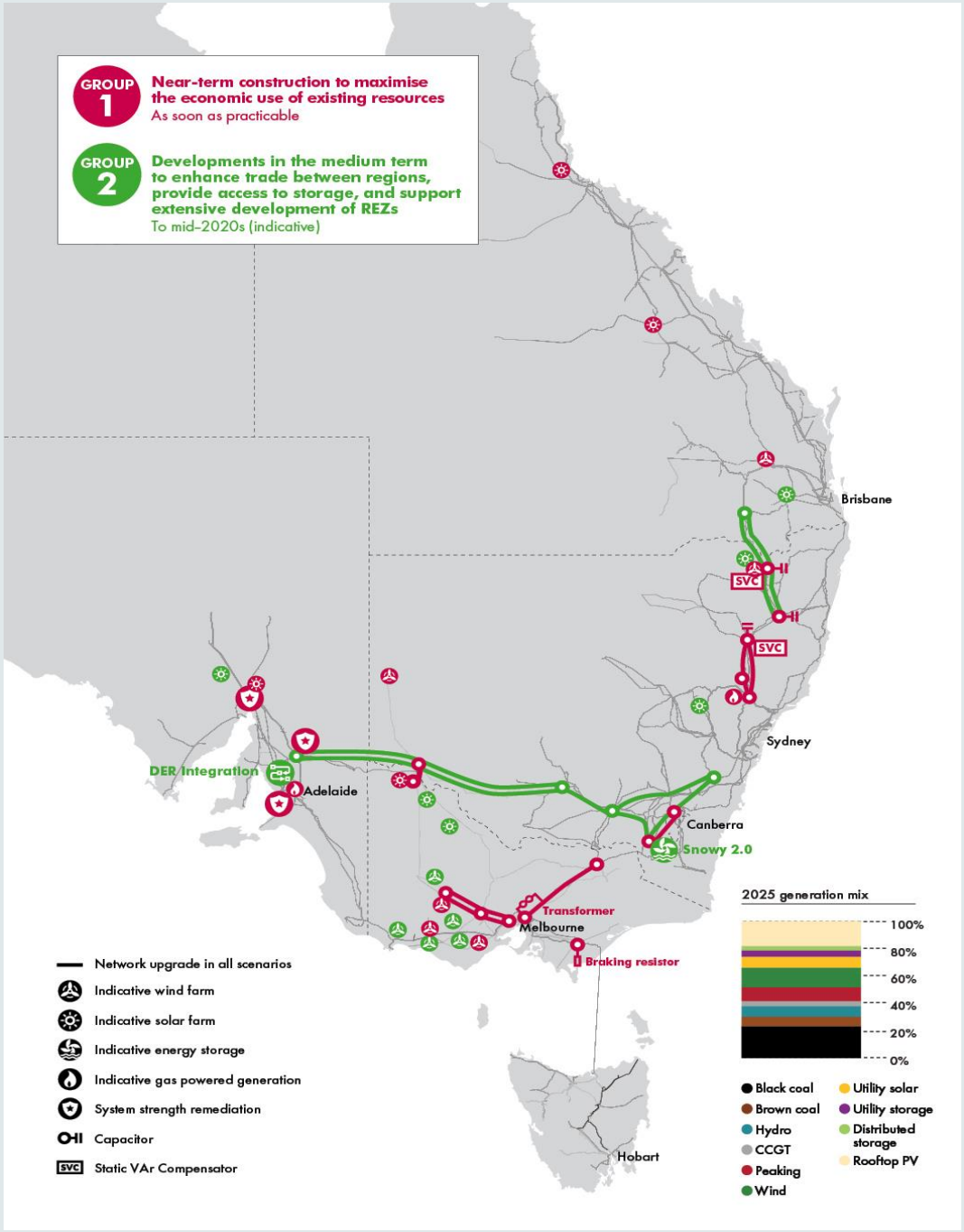
### Maximise economic use of existing resources



# Group 2

## Developments in the medium term

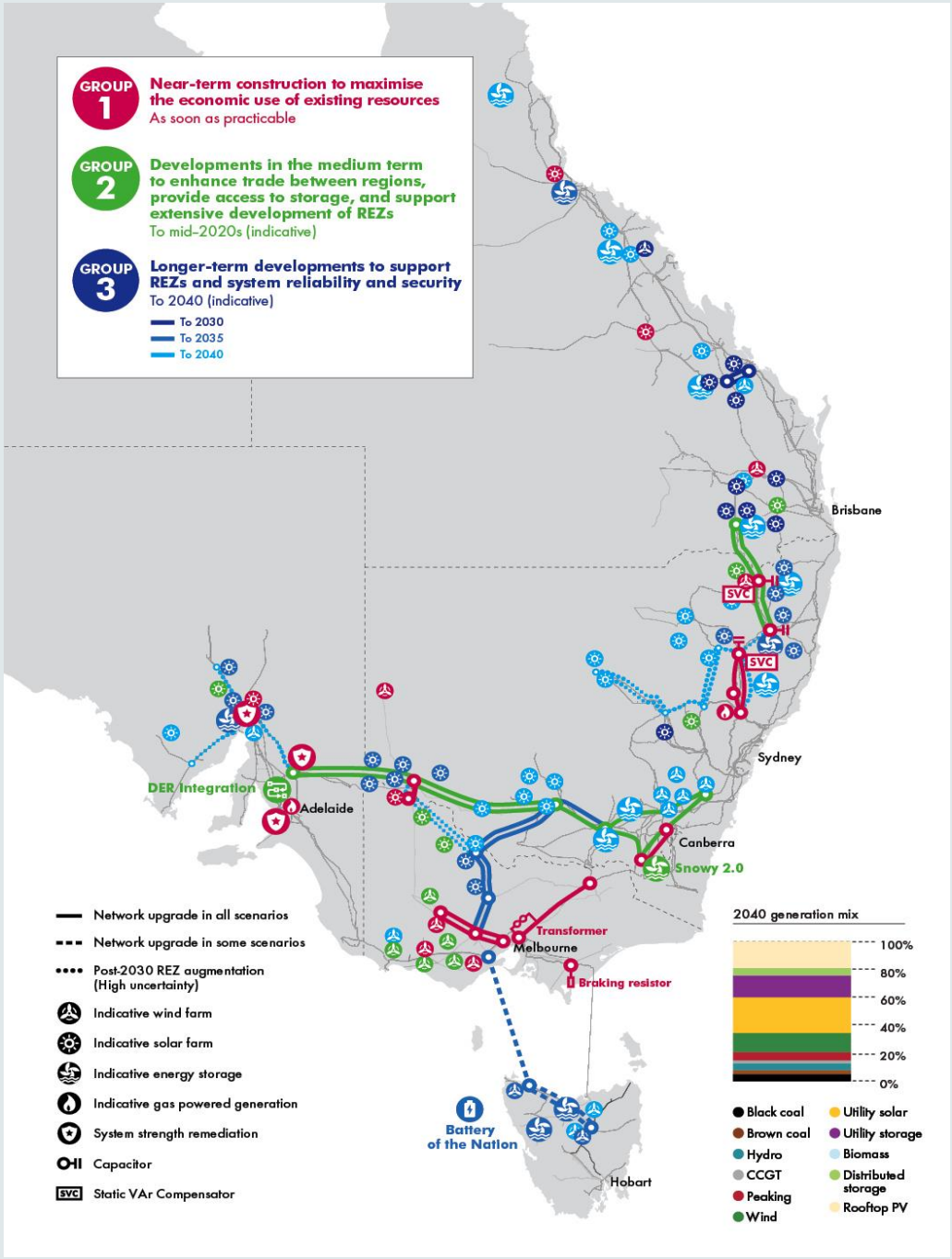
Enhance trade between regions, provide access to storage, and support extensive development of REZs



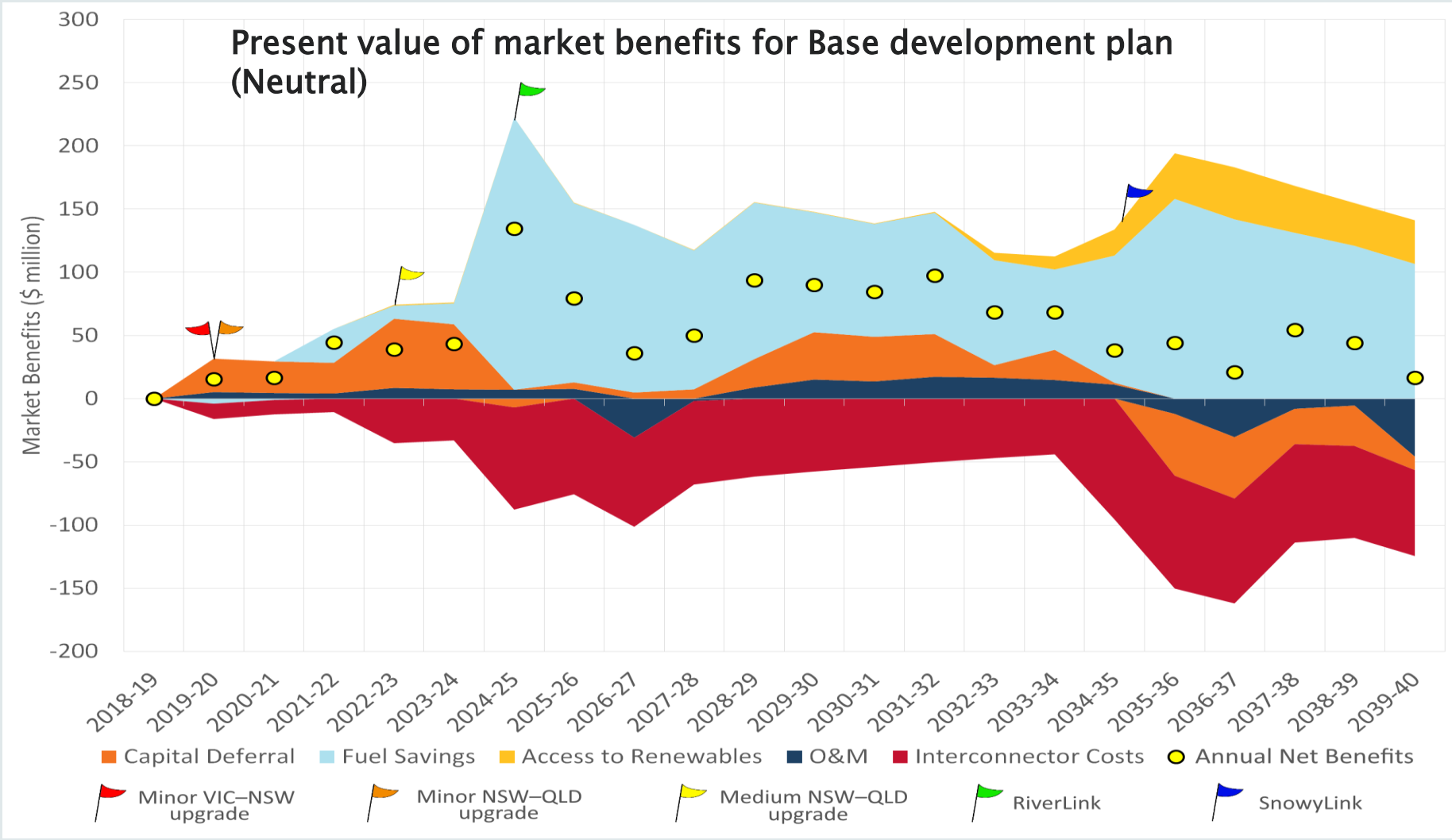
# Group 3

## Longer-term developments

Support REZs and system reliability and security



# Economic assessment – Neutral



# Economic assessments

The ISP base plan delivers value in all scenarios

| Scenario | Net benefits from interconnector upgrades ($ million) |
|---|---|
| **Central cases** | |
| Neutral | $1,192 |
| Neutral with storage initiatives | $1,249 |
| **Scenarios** | |
| Slow Change | $1,777 |
| Fast Change | $1,499 |
| High DER | $1,985 |
| **Sensitivities** | |
| Increased role for gas | $544 |

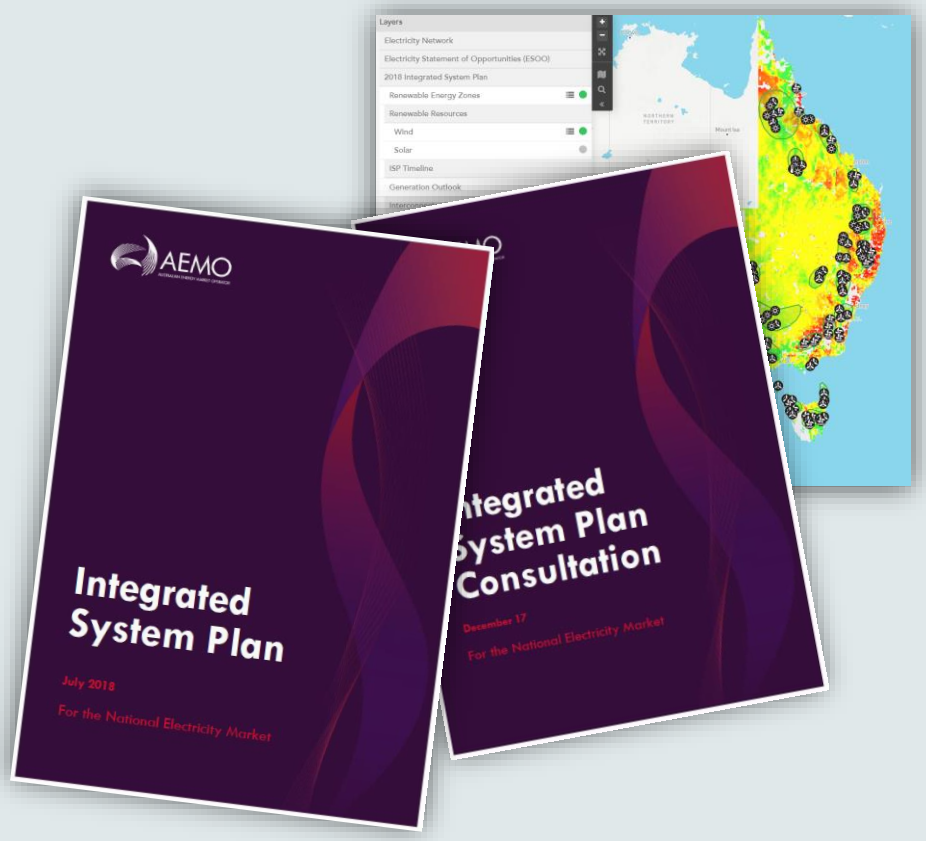
# ISP Published

**Previously published:**

- Consultation Paper
- Consultation submissions & summary
- Assumptions workbook

**Published yesterday:**

- ISP report with Appendices
- Input data and results
- Interactive map



# Q & A

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# Next steps

| Milestone | Timing |
|---|---|
| Draft report (PADR) published | 29 Jun 2018 |
| Public forum (Adelaide) | 18 Jul 2018 |
| Technical deep dive modelling workshop | Mid-Aug 2018 |
| Submissions due on PADR | 24 Aug 2018 |
| Further work to respond to AEMO Integrated System Plan and stakeholder submissions | Aug to Oct 2018 |
| Final report (PACR) | End Nov 2018 |
| AER makes ruling on final report | By April 2019 |


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